34. INTERSTELLAR MATTER AND PLANETARY NEBULAE
(MATIERE INTERSTELLAIRE ET NEBULEUSES PLANETAIRES)

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1. Introduction

(V. Radhakrishnan)

The subject of interstellar matter continues to be one of the most active fields of present day astronomical research. The advent of new instruments operating in the different parts of the electromagnetic spectrum has resulted in a phenomenal increase both in the amount of observational material, and in the theoretical work attempting to interpret or model the observations. This has made it increasingly difficult to cite all of the published work in the field, and to have room to report even in brief on the conclusions of these studies.

The following sections of the report cover the period 1979-81. In fitting them together within the space allotted for this Commission's report, duplication of references has been avoided as far as possible. For the same reason, the names of several journals have been shortened to their well recognised (but not IAU recommended) abbreviations: The Astrophysical Journal (Ap.J.), Astronomy and Astrophysics (A&A), Astronomical Journal (A.J.), Monthly Notices of the Royal Astronomical Society (MNRAS), Publications of the Astronomical Society of the Pacific (PASP), Bulletin of the American Astronomical Society (Bull. AAS), and the new Journal of Astrophysics and Astronomy (JAA).

We list below the more important books, conference proceedings, surveys, and review articles concerning this Commission and published since 1979.

MONOGRAPHS AND OTHER BOOKS

Adams, D.J.: 1981, "Cosmic X-ray Astronomy", Heyden & Son Inc., London.
Appenzeller, I., Lequeux, J., Silk, J.: 1980, "Star Formation", 10th Advanced Course, Swiss Society of Astronomy and Astrophysics, Saas-Fee, Geneva Observatory.
Dyson, J.E., Williams, D.A.: 1980, "The Physics of the Interstellar Medium", Manchester University Press.
Dolginov, A.Z., Gnedin, Yu. N., Silant'ev, N.A.: 1979, "Propagation and Polarization of Radiation through Cosmic Medium", Nauka, Moscow. (In Russian)
Kaplan, S.A., Pikel'ner, S.B.: 1979, "Physics of the Interstellar Medium", ed. N.G. Bochkarev, Nauka, Moscow. (In Russian)
Kislyakov, A.G. (ed.): 1979, "Spectral Investigations of Cosmical and Atmospheric Radiation", IPF, Gorkij.
Martin, P.G.: 1978, "Cosmic Dust: its impact on astronomy", Clarendon Press, Oxford.
Martinov, D. Ya. (ed.): 1981, "Stars and Stellar Systems", Nauka, Moscow. (In Russian)
Spitzer, L. Jr.: 1978, "Physical Processes in the Interstellar Medium", Wiley-Interscience.
van Woerden, H., Brouw, W.N., van de Hulst, H.C. (eds.): 1980, "Oort and the Universe", D. Reidel Publishing Co.
van de Hulst, H.C.: 1980, "Multiple Light Scattering", (Vols. 1 & 2), Academic Press, Inc.

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SYMPOSIUM REPORTS, CONFERENCE PROCEEDINGS, ETC.

Andrew, B.H. (ed.): 1980, "Interstellar Molecules" (IAU Symp. 87), D. Reidel Publishing Co.
Bernacca, P.L., Ruffini, R. (eds.): 1980, "Astrophysics from Spacelab" (Astrophysics and Space Science Library, Vol. 81), D. Reidel Publishing Co.
Chapman, R.D. (ed.): 1981, "The Universe at Ultraviolet Wavelengths" (The First Two years of IUE), NASA Conference Publication 2171 (NASA CP-2171).
Chiosi, C., Stalio, R. (eds.): 1981, "Effects of Mass-loss on Stellar Evolution" (IAU Colloq. 59, September 1980), Trieste Astronomical Observatory.
"Elements et leurs isotopes dans l'univers, Les": 1979, Liege XXII^{e} Colloque International d'Astrophysique, Universite de Liege, Institut d'Astrophysique.
Halliday, I., McIntosh, B.A. (eds.): 1980, "Solid Particles in the Solar System" (IAU Symp. 90), D. Reidel Publishing Co.
Iben, I. Jr., Renzini, A. (eds.): 1981, "Physical Processes in Red Giants" (Astrophysics and Space Science Library, Vol. 88), D. Reidel Publishing Co.
"Protostars and Planets": IAU Colloq. 52 (Tucson, Arizona), The Moon and the Planets, 1979, 19, 107-315 and 1979, 20, 3-101, D. Reidel Publishing Co.
Roger, D.S., Dewdney, P.E. (eds.): 1981, "Regions of Recent Star Formation" (Penticton Workshop, June 1981), D. Reidel Publishing Co.
Schuerman, D.W. (ed.): 1980, "Light Scattering by Irregularly Shaped Particles", Plenum Press.
Setti, G., Fazio, G.G. (eds.): 1978, "Infrared Astronomy" (NATO Advanced Study Institute, July 1977), D. Reidel Publishing Co.
Shaver, P.A. (ed.): 1980, "Radio Recombination Lines" (Astrophysics and Space Science Library, Vol. 80), D. Reidel Publishing Co.
Solomon, P.M., Edmunds, M.G. (eds.): 1980, "Giant Molecular Clouds in the Galaxy" (Third Gregynog Astrophysics Workshop), Pergamon Press.
"Spectres des Molecules Simples au Laboratoire et en Astrophysique, Les": 1980, Liege XXI^{e} Colloque International d'Astrophysique, Universite de Liege.
"Thermodynamics and Kinetics of Dust Formation in the Space Medium": 1979, Astrophysics and Space Science, Vol. 65, D. Reidel Publishing Co.
Willis, A.J. (ed.): 1979, "The First Year of IUE", NASA ESA SRC, University College London.
Wynn-Williams, C.G., Cruikshank, D.P. (eds.): 1981, "Infrared Astronomy" (IAU Symp. 96), D. Reidel Publishing Co.

CATALOGUES, SURVEYS, ETC.

Alloin, D., Collin-Souffrin, S., Joly, M.: 1979, "A Line-Intensity data compilation for a Sample of H II Regions", A&A Suppl., 37, 361.
Avedisova, V.S.: 1981, "Catalogue of Star Formation Regions, Part I", Sci. Inf. of Astron. Council of Acad. Sci. USSR.
Dixon, R., Sonneborn, G.: 1980, "A Master List of Nonstellar Optical Astronomical Objects", Ohio State University Press.
Parker, R.A.R., Gull, T.R., Kirshner, R.P.: 1979, "An Emission-line Survey of the Milky Way", NASA Special Publication 434.
Rossano, G., Craine, E.: 1980, "Near Infrared Photographic Sky Survey: a field index", Pachart Publishers.

REVIEW ARTICLES

Beckman, J.E., Moorwood, A.F.M.: 1979, "Infrared Astronomy", Rep. Prog. Phys., 42, 87.
Cesarsky, C.J.: 1980, "Cosmic-Ray Confinement in the Galaxy", Annu. Rev. Astron. Astrophys., 18, 289.
Felli, M.: 1979, "Properties of H II Regions" in Westerlund, B.E.(ed.), "Stars and Star Systems", D. Reidel Publishing Co., p. 195.
Goudis, C.: 1979, "A Classification of the Available Astrophysical Data of Particular H II Regions", Astrophys. Space Sci., 61, 417.

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Habing, H.J., Israel, F.P.: 1979, "Compact H II Regions and OB Star Formation", Annu. Rev. Astron. Astrophys., 17, 345.
McCray, R., Snow, T.P. Jr.: 1979, "The Violent Interstellar Medium", Annu. Rev. Astron. Astrophys., 17, 213.
McKee, C.F., Hollenbach, D.J.: 1980, "Interstellar Shock Waves", Annu. Rev. Astron. Astrophys., 18, 219.
Osterbrock, D.E.: 1980, "Physical Characteristics of Ionized Gaseous Nebulae", IAU Coll. 54, 99.
Savage, B.D., Mathis, J.S.: 1979, "Observed Properties of Interstellar Dust". Annu. Rev. Astron. Astrophys., 17, 73.
Seaton, M.J.: 1980, "Spectra of Gaseous Nebulae", Quart. J. Roy. Astron. Soc., 21, 229.
Terzian, Y.: 1980, "Planetary Nebulae", Quart. J. Roy. Astron. Soc., 21, 82.
Verschuur, G.L.: 1979, "Observations of the Galactic Magnetic Field", Fundam. Cosmic Phys., 5, 113.
Walsh, J.R.; 1980, "A Classification of the Available Astrophysical Data of Particular H II Regions - IX NGC 2264", Astrophys. Space Sci., 69, 227.
Wannier, P.G.: 1980, "Nuclear Abundances and the Evolution of the Interstellar Medium", Annu. Rev. Astron. Astrophys., 18, 399.
Whittet, D.C.B.: 1981, "The Composition of Interstellar Grains", Quart. J. Roy. Astron. Soc., 22, 3.
Zuckerman, B.: 1980, "Envelopes Around Late-type Giant Stars", Annu. Rev. Astron. Astrophys., 18, 263.

2. Physical State and Dynamical Processes

(J. Lequeux)

This review covers the literature from January 1979 to mid-1981, but does not pretend to be complete. Emphasis has been put on theoretical work, but some observational work is also cited. Overlaps with other sections are unavoidable. Amongst topics not, or very incompletely, covered here, I list atomic and molecular processes, interstellar chemistry, dust formation and destruction, acceleration of cosmic rays and their interaction with interstellar matter, and topics related to galactic structure.

The past three years of research have been dominated by the ever growing evidence that the interstellar medium (ISM) is in a state of buoyancy; in most situations only non-stationary models have a chance to give a possible representation of this medium. Emphasis has been put on the hydrodynamics of the various components and on their mutual interactions, in particular the role of shock waves due to supernovae, stellar winds and H II regions. Global models of the evolution of the ISM including mass exchange between the various components are starting to emerge. Models for the evolution of molecular clouds leading to star formation have been considerably refined and now include 3D hydrodynamical calculations. The reader should also look at the list of general references and review papers, some of which cover the present topics.

A. DIFFUSE CLOUDS (DCs)

General statistical studies have been published based either on 21-cm data (Crovisier, 1981, A&A, 94, 162; Dickey et al. 1979, Ap.J., 228, 465; Dickey et al. 1981, A&A, 101, 332) or on optical data (Knude, 1981, A&A, 97, 380). It appears that, although generally of smooth structure (Dickey, 1979, Ap.J., 233, 558), DCs contain denser regions with smaller velocity dispersions revealed by molecular-line studies (Dickey et al. 1981, A&A, 98, 271 ; Kazes and Crovisier, A&A, 101, 401). The hotter gas (the old "intercloud medium") appears to be pervasive but it is still not completely clear whether it only makes cloud envelopes or small clouds as predicted by the 3-component model of the ISM (Knude, 1979, A&A, 77, 198; Heiles,

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1980, Ap.J., 235, 833). There is increasing evidence for the presence of shocks inside DCs (Jenkins and Shaya, 1979, Ap.J., 231, 55) and the depletion in heavy elements is smaller or absent if strong motions are present (e.g. York and Kinahan, 1979, Ap.J., 228, 127; Chaffee and Dunham, 1979, Ap.J., 233, 568; Shull, 1980, Ap.J., 238, 560), presumably due to grain sputtering (Trivedi and Larimer, 1981, Ap.J., 248, 563). There have been relatively few studies of the physical conditions in DCs (Pottasch et al. 1979, A&A, 74, L15; Roberge et al. 1981, Ap.J., 243, 817; Shchekinov, 1979, Astron. Zh., 56, 809; Arshutkin and Kolesnik, 1980, Astrofiz., 16, 737; Arshutkin, 1980, Astrometr. Astrofiz., 41, 29). The fractionation of deuterium has been studied by Bruston et al. (1981, Ap.J., 243, 161). DC stability has been discussed by Hartquist et al. (1979, A&A, 75, 137), Flannery and Press (1979, Ap.J., 231, 688) and McMillan et al. (1980, Ap.J., 240, 488); the latter predict large internal fluctuations of temperature and pressure. Rosner and Hartquist (1979, Ap.J. Lett., 231, L83) show that rotating magnetized DCs can develop hot "coronae".

B. HOT INTERSTELLAR MEDIUM

The structure and origin of this component are still far from clear. A wide range of temperatures corresponding to various stages of ionization of O, C and Si is present. Soft X-ray observations are sensitive to bremsstrahlung and line emission from widely distributed gas with $T > 10^6$K (Inoue et al. 1979, Ap.J.Lett., 227, L85; Fried et al. 1981, Ap.J., 242, 987; Schnopper et al. 1981, Ap.J., in press). For calculations of this emission see Shull (1981, Ap.J.Suppl., 46, 27); this gas is usually believed to come from more or less merged supernova remnants and stellar winds (e.g. Chevalier and Oegerle, 1979, Ap.J., 227, 398; Higdon and Lingenfelter, 1980, Ap.J., 239, 867) and to occupy most of the IS volume (Dwek and Scalo, 1979, Ap.J. Lett., 233, L81). It is not clear whether the O VI absorption lines originate in this medium or mainly in cloud interfaces (Cowie et al., 1979, Ap.J., 232, 467). N V is less ubiquitous than O VI; when it is detected, the N V/O VI ratio suggests $T \simeq 2\text{-}3\ 10^5$K (Smith and Hartquist, 1980, MNRAS, 192, 73P; Morton and Bhavsar, 1979, Ap.J., 228, 147), but do N V and O VI coexist? Extreme UV observations, however, seem to point to the actual existence of temperatures in this range, maybe in cloud interfaces (Stern and Bowyer, 1979, Ap.J., 230, 755). The C IV and Si IV lines appear to originate mainly in H II regions surrounding the observed hot stars (Smith et al. 1980, MNRAS, 191, 339; Black et al. 1980, Ap.J., 239, 502; Cowie et al. 1981, Ap.J., 248, 528) although some probably come from either a "semitorrid gas" (Bruhweiler et al. 1979, Ap.J. Lett., 229, L39; 1980, Ap.J., 237, 19) or expanding shells (Cowie et al. op. cit.). This point has an obvious bearing on the still uncertain nature of the hot halo seen in these lines around our Galaxy (Savage and de Boer, 1979, Ap.J. Lett., 230, L77; Hartquist and Tallant, 1981, MNRAS, 196, 527) and perhaps around the Magellanic Clouds (de Boer and Savage, 1980, Ap.J., 238, 86; Savage and de Boer, 1981, Ap.J., 243, 460; see, however, Prevot et al. 1980, A&A, 90, L13). Instabilities in the hot ISM have been suggested to be responsible for interstellar scintillation (Hall, 1980, MNRAS, 190, 353; 1981, MNRAS, 195, 685; see also Chashej and Shishov, 1980, Pis'ma Astron. Zh., 6, 574 and Pynzar and Shishov, 1980, Astron. Zh., 57, 1187). Ionization conditions under X-ray heating have been studied by Bochkarev (1980, Pis'ma Astron. Zh., 6, 289) and Beigman et al. (1981, preprint).

C. MOLECULAR CLOUDS (MCs)

Observations of MCs and their chemistry are reviewed elsewhere. I only want to point out that it is very difficult to obtain from comparisons of molecular line observations with models entirely convincing pictures of the physical conditions and dynamics of these clouds (see e.g. Stenholm, 1980, A&A, 92, 142 and references therein). However, some MCs at least appear definitely clumpy (e.g. Bastien et al. 1981, A&A, 98, L4). Statistics on MCs have been discussed e.g. by Stark (1979, Ph.D. Thesis, Princeton) and Rowan-Robinson (1979, Ap.J., 234, 111). Radiation transfer and heating of dust in MCs have been discussed by Rowan-Robinson (1980, Ap.J. Suppl. 44, 403), Brand (1979, A&A, 71, 47), Rouan (1979, A&A, 79, 102

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and 1980, A&A, 87, 169), Natta et al. (1981, A&A, 99, 289), Flannery et al. (1980, Ap.J., 236, 598), Keene et al. (1980, Ap.J.Lett., 240, L43), Keene (1981, Ap.J., 245, 115). The gas temperature is never smaller than ≃ 5K (Zuckerman and Kuiper, 1980, Ap.J., 235, 840; Evans et al. 1980, Ap.J., 239, 839) and it appears that even in hot regions gas can be heated by molecule collisions with dust grains (Phillips et al. 1981, Ap.J., 245, 512). The 21-cm line has been seen in self-absorption in MCs by many authors; the interpretation of these observations is not easy (Levinson and Brown, 1980, Ap.J., 242, 416). It is not clear whether the corresponding H I only forms envelopes or is more distributed (see e.g. Bowers et al. 1980, Ap.J., 241, 183; Sherwood and Wilson, 1981, A&A, 101, 72). Ionization and its consequences have been studied by Wootten et al (1979, Ap.J., 234, 876), Elmegreen (1981, Ap.J., 232, 729), Guelin et al. (1981, A&A, in press); the ionization fraction is 10^{-7} to 10^{-8}. Vrba et al. (1981, Ap.J., 243, 489) and Goldreich and Kylafis (1981, Ap.J. Lett., 243, L75) deal with the magnetic field. Thermal-chemical models are built by Viala et al (1979, A&A, 73, 174) and steady-state global models by de Jong et al. (1980, A&A, 91, 68). Fleck (1980, Ap.J., 242, 1019; 1981, Ap.J.Lett., 246, L151) has studied MCs stabilized by turbulence, while Norman and Silk (1980, Ap.J., 238, 158) propose a self-consistent model where MCs are stabilized by winds from T Tauri stars continuously formed inside.

D. THE ROLE OF SHOCK AND IONIZATION FRONTS

An enormous body of relevant observations has been recently accumulated; there is now ample evidence that the ISM is full of loops, shells, super-shells and patches, and high velocity gas associated with such phenomena. The following papers deal with the physics of these shocks and the corresponding radiation: Raymond (1979, Ap.J.Suppl., 39, 1), Hollenbach and McKee (1979, Ap.J., 41, 555), Canto and Dyson (1979, A&A, 76, 318), Shull and McKee (1979, Ap.J., 227, 131), Draine (1980, Ap.J., 241, 1021), Cowie et al. (1981, Ap.J., 247, 908), Zentsova and Urpin (1980, Astrofiz., 16, 553). Several papers deal with the effects of stellar winds and supernovae inside MCs, with emphasis on their possible detection: Shull (1980, Ap.J., 237, 769 and 238, 860), Wheeler et al. (1980, Ap.J., 237, 781), Wright (1980, Ap.J. Lett., 242, L23), Draine (1981, Ap.J., 245, 880). Bubbles and superbubbles require an energy of the order of 10^{53} ergs or more if they expand in an average-density ISM (e.g. Heiles, 1979, Ap.J., 229, 533) requiring winds from hundreds of OB stars or many supernova explosions. If the medium is of very low density, one or a few events may suffice (Davelaar et al. 1980, A&A, 92, 231 and 97, 413; Higdon, 1981, Ap.J., 244, 88). These conditions can be met in OB associations (Tomisaka et al. 1981, Astrophys. Space Sci., 78, 273; Bruhweiler et al. 1980, Ap.J.Lett., 238, L27). The energy problem for the supergiant holes seen in H I pictures of external galaxies is even worse; Tenorio-Tagle (1980, A&A, 88, 61; 1981, A&A, 94, 338) has suggested that they are due to collisions of high-velocity clouds with the gas disk (see also Holder, 1980, MNRAS, 191, 417). There is consensus that Herbig-Haro objects and bipolar nebulae are formed by stellar winds emitted by very young stars, possibly collimated (Canto, 1980, A&A, 86, 327; Hippelein and Munch, 1981, A&A, 99, 248; Schwartz and Dopita, 1980, Ap.J., 236, 543; Canto and Rodriguez, 1980, Ap.J., 239, 982; Schwartz, 1981, Ap.J., 243, 197; Canto et al., 1981, Ap.J., 244, 102; Icke, 1981, Ap.J., 247, 152). The complex phenomena observed around IRc2 and KL in the Orion MC and in W51, including the fast-moving H_2O masers (Genzel et al. 1979, A&A, 78, 239; Downes et al. 1981, Ap.J., 244, 869; Genzel et al. 1981, Ap.J., 244, 884 and 247, 1039) are usually interpreted as the effect of a stellar wind (Norman and Silk, 1979, Ap.J., 228, 197; Solomon et al. 1981, Ap.J. Lett., 245, L19). Instabilities of ionization shock fronts have been shown to lead to the formation of elephant trunks, globules and may even trigger star formation (Giuliani, 1979, Ap.J., 233, 280 and 1980, Ap.J., 242, 219; Schneps et al. 1980, Ap.J., 240, 84; Brand, 1981, MNRAS, 197, 217; Welter and Schmid-Burgk, 1981, Ap.J., 245, 927; Shchekinov, 1979, Astrofiz. 15, 347). The interaction between stellar winds and the ISM has been studied by Kahn (1980, A&A, 83, 303) and Dopita (1981, Ap.J., 246, 65). Star formation following gas accretion by a MC has been studied by Icke (1979, A&A, 78, 352). The interaction of bubbles to form tunnels has been modelled by Jones et

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al. (1979, Ap.J., 232, 129) and the mechanical heating of the ISM by supernova remnants by Cox (1979, Ap.J., 234, 863 and 1981, Ap.J., 245, 534).

E. EVOLUTION OF THE ISM

We are still far from possessing a complete, self-consistent theory of the ISM. However, partial aspects have been studied in detail. The formation of H II regions on the side of MCs (the "champagne" or "blister" model) is described in a series of papers by Tenorio-Tagle and collaborators (see 1981, A&A, 99, 305 and references therein) and by Icke and collaborators (1979, Ap.J., 234, 615; 1980, Ap.J., 236, 808; 1981, Ap.J.Suppl., 45, 585). The hydrodynamics of cloud collisions which leads to partial coalescence and partial disruption has been studied by Smith (1980, Ap.J., 238, 842), Hausman (1981, Ap.J., 245, 72), Handbury et al. (1979, A&A, 77, 152) and Chieze and Lazareff (1980, A&A, 91, 290); the latter have calculated the equilibrium mass spectrum of the diffuse clouds (see also Kwan, 1979, Ap.J., 229, 567 and Cowie, 1980, Ap.J., 236, 868 and 1981, Ap.J., 245, 66). Whether the giant MCs are formed by coalescence (see e.g. Scoville and Hersh, 1979, Ap.J., 229, 578) is disputed. An alternative possibility is the collapse and fragmentation of large H I complexes formed in spiral arms (Blitz and Shu, 1980, Ap.J., 238, 148; Elmegreen, 1979, Ap.J., 231, 372; Polyachenko et al. 1980, Astron. Zh., 57, 497 and Morozov, 1981, Pis'ma Astron. Zh., 7, 9) possibly helped by the Parker instability (Elmegreen, 1981, preprints). Some authors have proposed that turbulence possibly generated by galactic differential rotation determines the rotation and the fate of IS clouds (Larson, 1979, MNRAS,186, 479 and 1981, MNRAS, 194, 809; Fleck and Clark, 1981, Ap.J., 245,898). The damping of the motion of MCs in the Galaxy has been studied by Elmegreen (1981, Ap.J., 243, 512) and Surdin (1980, Astr. Circ. URSS No. 1113) and shown to be efficient. Disruption of MCs by HII regions has been studied in the framework of the blister model (see above, and Whitworth, 1979, MNRAS, 186, 59; Mazurek, 1980, A&A, 90, 65), and the propagation of star formation in a cloud complex has been discussed by Bedijn and Tenorio-Tagle (1980, A&A, 88, 58). A dynamical model for formation of neutral clouds in the halo (the "galactic fountain") has been studied by Bregman (1980, Ap.J., 236, 577) and Cox (1981, Ap.J., 245, 534). Semi-empirical global models of massive cloud evolution and star formation in the Galaxy have been built by Bania and Lyon (1980, Ap.J., 239, 173), Bash et al. (1981, Ap.J., 245, 92), Levinson and Roberts (1981, Ap.J., 245, 465) and Huntley and Gerola (1981, Ap.J. Lett., 248, L69).

3. Neutral Atomic Hydrogen (H I)

(U. Mebold)

Since photographic presentations of the H I distribution over nearly the entire sky have become available, the main emphasis now in 21-cm line research is on investigations of filamentary structures and their relations to radio- optical- or X-ray features like supernova remnants (SNR), H II regions, stellar associations etc.

New 21-cm line surveys have led to complete sky coverage: Kerr et al. (1981, A&A Suppl., 44, 63) present a 21-cm line longitude-velocity map of the galactic equator for $231^\circ \leq \ell \leq 350^\circ$ and latitude-velocity maps for $|b| \leq 4^\circ$ and $263^\circ \leq \ell \leq 343^\circ$ obtained with the Parkes 64 m telescope. Together with the Maryland-Greenbank H I survey (Westerhout, 1975, available at the University of Maryland, College Park) and the galactic center survey ($338.5 \leq \ell \leq 11^\circ$, $|b| \leq 2^\circ$) of Sinha (1979, A&A Suppl., 37, 403) the equator profiles have been combined into a longitude-velocity map for the entire 360° of the galactic equator (Kerr et al. 1980, Bull AAS, 12, 457). The completely sampled Parkes 18 m telescope survey by Jackson et al. (1980, Bull. AAS, 12, 457) covers the range $240^\circ \leq \ell \leq 350^\circ$, $|b| \leq 10^\circ$ and thus extends the $10^\circ \leq \ell \leq 250^\circ$ coverage of the Hat Creek Survey by Weaver and Williams (1973, A&A Suppl., 8, 1). Maps of the Pulkovo sky survey of the hydrogen 21-cm line have been published by Bystrova (1980, Nauka, Leningrad). The Parkes 18 m telescope survey at δ <-30° and $|b| \geq 10°$ by Cleary has been combined with the Hat Creek Survey and published as a synoptic view of the Galaxy ($|b| > 10°$, $-90 < V < +70$ km s^{-1}) by Cleary et al. (1979, A&A Suppl. 36, 95; see also Heiles and Cleary, 1979, Australian J. Phys. Astrophys. Suppl., 47, 1). The results of the surveys carried out by the Argentine groups Poppel et al. and Bajaja et al. (both 1979, First Latin-American Regional Astronomy Meeting, hereafter FLARAM, p. 188 and 183) using the 30 m telescope at Parque Pereyra have been partly discussed (Colomb et al. 1980, A&A Suppl., 40, 47; Morras, 1979, Ap. Lett., 20, 45; Strauss et al. 1979, A&A, 71, 319; Olano and Poppel, 1981, A&A, 94, 151) or presented in the form of longitude-velocity and of latitude-velocity maps (Bajaja et al. 1980, A&A Suppl., 41, 67; Bajaja and Morras, 1980, A&A Suppl., 41, 121).

The distribution and motion of the gas in the inner few kpc of the Galaxy has been reviewed by Burton and Liszt (1979, IAU Symp. 84, 325) and Liszt (1980, Highlights of Astronomy, 5, 149). Further studies were undertaken by Cohen and Davies (1979, MNRAS, 186, 453), Cohen (1979, IAU Symp. 84, 337), Sinha (1979, op. cit. and 1979, IAU Symp. 84, 341), Gusten and Downes (1981, A&A, 99, 27) and others (Alferova et al. 1980, Pis'ma Astron. Zh., 6, 759). The available data led Davies and Cohen to conclude that the gas is concentrated in spiral dustlanes of the type seen in the nucleus of M31 while Burton and Liszt (op. cit. and Liszt and Burton, 1980, Ap.J., 236, 779) conclude that no important density enhancements or anisotropic ejection from the nucleus is required.

A comprehensive review of the large-scale characteristics of the galaxy is given in the proceedings of the IAU Symposium No. 84 (1979). The rotation parameters (Gunn et al. 1979, A.J., 84, 1181; Petrovskaya, 1979, Pis'ma Astron. Zh., 5, 632; Petrovskaya and Korzin, 1980, Abastumansk. Obs. Bull., 52, 33 and 52, 36), the thickness of the galactic H I layer as a function of galactic radius (Celnik et al. 1979, A&A, 76, 24), the surface density, the warping and the thickness in the outer parts of our Galaxy (Henderson and Jackson, 1980, Bull. AAS, 12, 456; Kulkarni et al. 1980, Bull. AAS, 12, 523) have been discussed in more detail since then. An observed latitude dependence of the rotation curve of the Galaxy is found to affect the previously determined (Gunn et al. op. cit.) rotation parameters of the Galaxy (1981, Lockman and Bania, Bull. AAS, 13, 538; Jackson and Kerr, Bull. AAS, 13, 538). A determination of the parameters of the spiral structure of the Galaxy from the H I line and linear and non-linear density wave theory was published by Berman and Mishurov (1978, Astrofiz., 14, 637, 1980, Astrofiz., 16, 73).

Selected areas of the galactic plane have been investigated by various groups. Baker and Burton used the 1000-foot Arecibo telescope to examine most of the galactic plane accessible to that telescope (1979, A&A Suppl., 35, 129). Greisen and Lockman observed the H I absorption towards NGC 7538, DR7 and W31 to study the kinematics and distribution of cool H I clouds (1979, Ap.J., 228, 740). The Puppis window of the Galaxy was studied by Stacy and Jackson (1980, Bull. AAS, 12, 458), the sky around W33 by Sato and Akabane (1979, Ann. Tokyo Astron. Obs., 17, 119), the lines of sight towards seven low latitude pulsars by Weisberg et al. (1980, A&A, 88, 84), towards SS433 by van Gorkom et al. (1980, A&A, 82, L1) and towards the radio source CL4 by Payne and Bania (1979, A.J., 84, 611). H I between spiral arms has been studied by Gosachinskij and Rakhimov (1978, Soviet Astron. 22, 12 and 172). Cloud structure between arms has been found.

The distribution and kinematics of the more local H I gas has been discussed by Chlewicki (1980, Acta Astron., 30, 299) who investigated the structure of the local spiral arm. Burton and Moore (1979, A.J., 84, 189), Moore and Burton (1979, IAU Symp. 84, 535) and Giovanelli (1980, Ap.J., 238, 554) investigated the high-velocity H I streams in the galactic anticenter region. An H I feature situated mainly in Vulpecula and Delphinus is discussed by Bystrova (1980, Pis'ma Astron. Zh., 6, 39). A photographic presentation of southern and northern H I data at $|b| \geq 10°$ is presented by Colomb et al. (1980, A&A Suppl., 40, 47; 1979, FLARAM, p.195). H I line profiles at positive latitudes were decomposed into Gaussians by Takakubo (1978, Sci. Rep. Tohoku Univ. I., 61, 1). The column density of H I gas and its relation to galaxy counts has been discussed by Lebrun (1979, A&A, 79, 153). The gas to dust ratio has been determined from 21-cm line data towards 77 globular clusters by Mirabel and Gergely (1979, A&A, 77, 110). Heiles et al. confirm the existence of H I gas without reddening (1981, Ap.J.Lett., 247, L73) by demonstrating that 21-cm line stray-radiation is not adequate to mimic this effect (Kalberla et al. 1980, A&A, 82, 275). Significant upper limits on the gas content of globular clusters were set by Bowers et al. (1979, Ap.J., 233, 553).

The discovery of H I shells and supershells in our Galaxy by Heiles (1979, Ap.J., 229, 533; 1979, IAU Symp. 84, 301), Weaver (1979, IAU Symp. 84, 295) and Hu (1980, Bull. AAS, 12, 468) has led to a large number of investigations on the association of H I shells with stellar associations, H II regions and supernova remnants: The association of H I gas with stellar associations and/or H II regions was studied for λ Orionis and the Sco OB2 association by Bystrova (1980, Pis'ma Astron. Zh., 6, 579; 1979, Bull. Special Astrophys. Obs. North Caucasus, 11, 185), by Olano and Poppel for the Sco OB2 association (1981, A&A, 95, 316), by Arnal and Franco for the Chamaeleon T-Association (1979, FLARAM, p. 136) and by Read (1980, MNRAS, 193, 487) for the Ceph OB3 association. The association of H I structures with SNR's and/or radio continuum loops was studied by: Heiles et al. for the North Polar Spur (1980, Ap.J., 242, 533), Giovanelli and Haynes for the SNRs IC 433 and the Cygnus Loop (1979, Ap.J., 230, 404), Landecker et al. for the SNR G78.2+2.1 (1980, A&A Suppl., 39, 133), Colomb and Dubner for the SNR G261.9+5.5 (1980, A&A, 82, 244 and 1979, FLARAM, p. 175), Reich and Braunsfurth for the SNRs CTB1, G116.5+1.1 and G114.3+0.3 (1981, A&A, 99, 17), Reynolds and Ogden (1979, Ap.J., 229, 942) for the I Orion OB association, Barnard's loop and the Hα filaments in Eridanus, Ariskin for large-scale structures with associated H II regions that are weak radio-emitters (1979, Astron. Zh., 56, 997), Dolidze for two local details of the Orion arm (1980, Pis'ma Astron. Zh., 6, 745) and Bystrova (1979, Astrofiz. Issled. Izv. Spets. Astrofiz. Obs. Zelenchukskaya, 11, 244 and Bull. Spec Astrophys. Obs. North Caucasus, 11, 191) for the Cetus-Eridanus H I complex, two supposed SNR's (1978, Astron. Tsirk. 1014, 1) and other objects (1980, Pis'ma Astron. Zh., 6, 39). From RATAN-600 observations Alferova et al. (1979, Astron. Zh., 56, 1191) have discovered a red-shifted expanding and rotating H I envelope around the Orion nebula. Sato has estimated the distance of SNR G46.8-0.3 from H I emission-absorption features (1979, Ap. Lett., 20, 43). Bruhweiler et al. (1980, Ap.J.Lett., 238, L27) explain the H I shells and supershells as a natural byproduct of the interaction of stellar winds and supernovae, originating from stars in OB associations, with the surrounding interstellar gas.

The observational properties of high-velocity clouds (HVCs) have been reviewed by Hulsbosch (1979, IAU Symp. 84, 525). A new survey of HVCs has been conducted by Giovanelli in the declination range -10^{o} to $+50^{o}$ and the velocity range -900 km s^{-1} to $+900$ km s^{-1} (1979, IAU Symp. 84, 541 and 1980, A.J., 85, 1155). Observations of HVCs are reported and discussed also by Mirabel and Cohen (1979, IAU Symp. 84, 545), Cohen and Mirabel (1979, MNRAS, 186, 217), Cohen and Ruelas Mayorga (1980, MNRAS, 193, 583), and Morras (1980, A&A, 92, 315).

The Westerbork Synthesis Telescope has been used by Schwarz and Oort (1981, A&A, 101, 305) for a study of the fine structure of the HVC AI. The fine structure features lie embedded in a large cloud; their kinetic temperatures may be ∿ 50K, while that of the large cloud is in excess of ∿ 1000K. Payne et al. (1980, Ap.J., 240, 499) report the detection of 21-cm line absorption in a few HVCs and derive harmonic mean spin temperatures of a few hundred K. Rudnitskij and Pashchenko (1979, Astron. Zh., 56, 1115) have given an upper limit on the OH abundance in HVCs: $N_{OH}/N_{H\ I} < 8.5\times10^{-6}$. Heiles finds that the internal velocity structure of the HVCs is that expected for an expanding shell or supershell (1979, PASP, 91,

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611). Distance estimates for HVCs and condensations in the northern tip of the Magellanic Stream were made by Watanabe (1979, Bull. AAS, 11, 416 and 1979, PASP, 91, 616) on the basis of a conventional tidal disruption theory. The origin of HVCs has been discussed by Shchekinov (1980, Astrofiz., 16, 265) and Doroshkevich and Shandarin (1979, Astron. Zh., 56, 475). Taff (1979, Bull. AAS., 11, 413) presents evidence that the source of some of the HVCs are globular clusters. The small scale structure of the Magellanic Stream was investigated by Mirabel et al. (1979, MNRAS, 186, 433). They find no evidence for variation in cloud parameters along the Stream. Wright (1979, Ap.J., 233, 35) discusses the HVC close to M33 and concludes that it is probably associated with other HVCs in that general direction; see also Giovanelli (1979, IAU Symp. 84, 541).

Atomic hydrogen associated with molecular clouds has been studied by several groups. Read (1980, MNRAS, 192, 11; 1981, 194, 863; 1981, 195, 371) has used the Cambridge Half-Mile Telescope to study the H I complexes associated with NGC 7538, W3 and W58 respectively. Features are found closely associated with the H II regions which are probably due to photo-dissociation of gas close to the H II region ionization front. Other features in the H I correlate with the molecular distribution and suggest fractional abundances of atomic hydrogen in the molecular clouds ranging up to 0.5 per cent. Similar results have been obtained by Roger and Pedlar (1981, A&A, 94, 238) in a study of NGC 281 and by Mufson et al. (1981, Ap.J., 248, 992) for M16. Larger scale structure of atomic hydrogen in molecular clouds has been studied by the Japanese group (1979, IAU Symp. 87, 159 and 187) who have used the Maryland-Greenbank 21-cm survey to examine self absorption features in the H I close to M17 and W3. Liszt et al. (1981, Ap.J., 246, 74) discuss the extent to which H I profiles in the galactic plane are influenced by the residual (generally cold) atomic hydrogen contained in molecular clouds. They conclude that atomic hydrogen in molecular clouds tends to have a blanketing effect close to the H I terminal velocity and that this may seriously bias the determination of galactic structure from 21-cm measurements. Atomic hydrogen is clearly an important feature in molecular clouds.

This statement is also valid for the cold dark dust complexes in the solar neighbourhood. Several groups have attempted to look for correlations between atomic hydrogen column density obtained from 21-cm line absorption or self absorption measurements and either dust or molecular column densities. Liszt and Burton find a good correlation of H I with CO unit-velocity column density (1979, Ap.J., 228, 105) while Kazes and Crovisier (1981, A&A, 101, 401) do not find such a correlation. Winnberg et al. (1980, A&A, 90, 176) have studied the high latitude cloud L134 using measurements made at Effelsberg and Parkes. Bowers et al. (1980, Ap.J., 241, 183) have made a similar survey of the Southern Coalsack with the Parkes dish. Other recent articles on the same subject are by Mattila and Sandell who examine the dark nebula Lynds 1778/1780 (1979, A&A, 78, 264), by Sherwood and Wilson (1981, A&A, 101, 72) and by Batrla et al. (1981, A&A, 96, 202) who examine two clouds in the Taurus complex. The ratio by number of molecular to atomic hydrogen is found to vary between 400 and 1600 in these regions. It is rather unclear what is responsible for these variations. A critique of the methods used by radio observers to analyse such self absorption data is given by Levinson and Brown (1980, Ap.J., 242, 416). As often in such cases, one finds that there is no very satisfactory approach. A ratio of $(1.3 \pm 0.25) \times 10^{-5}$ for D/H has been derived by Ferlet et al. for the γ Cas line-of-sight (1980, Ap.J., 242, 576) and of $< 5.8 \times 10^{-5}$ by Ananthamaiah and Radhakrishnan (1979, A&A, 79, L9) from radio observations towards the galactic centre.

On the theoretical side, a detailed attempt to understand the conversion of atomic to molecular hydrogen has been made by Federman et al. (1979, Ap.J., 227, 466). Green and Truhlar investigate the rotational excitation of H_2 by collisions with H I atoms (1979, Ap.J., 231, L101). Barr and McNally (1980, MNRAS, 192, 669) *discuss the influence of H2 formation on the dynamics of a collapsing cloud.*

The global physical characteristics of the H I gas have been discussed by Baker (1979, IAU Symp. 84, 287). H I emission and absorption studies were undertaken with the 1000-foot Arecibo telescope by Dickey (1979, Ap.J., 233, 558) and Crovisier et al. (1980, A&A Suppl., 41, 229) towards extragalactic radiosources and by Dickey et al (1981, A&A, 101, 332) towards pulsars. The statistical properties of H I absorption features were studied by Crovisier (1981, A&A, 94, 162). An interpretation in terms of a ubiquitous "not strongly absorbing" component plus a "cloud component" of adjustable temperature is presented by Dickey et al. (1979, Ap.J., 228, 465) while Mebold et al. present evidence for warm (≳100K) envelopes around the absorbing clouds (A&A, in press). The "pervasiveness" of the "not strongly absorbing" H I gas is discussed by Heiles (1979, Bull. AAS, 11, 684).

H I clouds of exceptionally low column density ($N_{H\ I} \gtrsim 0.2 \times 10^{20}$ cm^{-2}) were found by Kalberla et al. (1980, A&A Suppl., 39, 337); a cloud of exceptionally low temperature ($T_s \gtrsim$ 20K) is discussed by Crovisier and Kazes (1980, A&A, 88,329). Evidence for a large population of shocked interstellar H I clouds is presented by Radhakrishnan and Srinivasan (1981, JAA, 1, 47), Radhakrishnan and Sarma (1980, A&A, 85, 249) and Shaver et al. (A&A, in press). Supporting evidence is reported by Cowie et al. (1979, Ap.J.Lett., 229, L81), DeNoyer (1979, Ap.J.Lett., 232, L165), Federman (1980, Ap.J.Lett., 241, L109), Ferlet et al. (1980, Ap.J., 242, 576) and Anantharamaiah et al. (1981, Second Asian-Pacific Regional Meeting, in press). Theoretical models for the interaction of H I clouds with SNR-shock fronts are presented by Chieze and Lazareff (1980, A&A, 91, 290) and by Tsunemi and Inoue (1980, Publ. Astron. Soc. Japan, 32, 247). Local values for the H I density and temperature were derived by Baliunas and Dupree towards λ And ($n \sim 0.03 - 0.08$ cm^{-3}) (1979, Ap.J., 227, 870), by Anderson and Weiler towards HR 1099 ($n \sim 0.006 - 0.012$ cm^{-3}) (1979, PASP, 91, 431) and by Meier from solar backscatter radiation for the immediate solar neighbourhood (1980, A&A, 91, 62).

Possible population inversions in the 21-cm line under intense plasma turbulence is discussed by Kaplan et al. (1979, Pis'ma Astron. Zh., 5, 345). Electromagnetic transitions (1981, A&A, 94, 194) and photoionization (1980, Ap.J., 242, 828) of hydrogen atoms in magnetic fields of $\sim 3 \times 10^{12}$ gauss were examined by Wunner and Ruder, and Schmidt et al. respectively.

4. Interstellar Molecules

(B. Zuckerman)

The frenetic pace that characterized the study of interstellar molecules during the early 1970's has been replaced by a more relaxed tempo. But the field is certainly not moribund and the construction of large new millimeter and submillimeter telescopes and interferometers should ensure a steady stream of exciting discoveries during the 1980's.

A. NEW MOLECULES

The following molecules were detected at millimeter wavelengths and identified during the past three years: NO (Liszt and Turner 1978, Ap.J.Lett., 224, L73); C_4H (Guelin et al. 1978, Ap.J.Lett., 224, L27); CH_3SH (Linke et al. 1979, Ap.J.Lett., 234, L139); HNCS (Frerking et al. 1979, Ap.J.Lett., 234, L143); CO^+ (Erickson et al. 1981, Ap.J.Lett., 245, L83); HCS^+ and either $HOCO^+$ or HOCN (Thaddeus et al. 1981, Ap.J.Lett., 246, L41; Gudeman et al. 1981, Ap.J.Lett., 246, L47).

Neutral carbon was detected at submillimeter wavelengths in molecular clouds (Phillips et al. 1980, Ap.J.Lett., 238, L103). Although not a new molecule per se, the study of this abundant species in and around molecular clouds promises to link the diffuse and the dark clouds and to clarify their chemistry. The transition

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frequency was measured by Saykally and Evenson (1980, Ap.J.Lett., 238, L107).

C_2H_4 was detected in the infrared in IRC +10216 (Betz, 1981, Ap.J.Lett., 244, L103).

B. ISOTOPIC STUDIES

The major aim of isotopic studies is to disentangle the true isotopic ratios from the observational data. Various effects including, for example, optical depth, chemical fractionation, and non-equilibrium excitation, must be correctly accounted for. Herein lies much of the effort expended by the authors of the following articles.

Wannier and Linke (1978, Ap.J., 225, 130) studied a variety of isotopes in IRC +10216. Turner and Zuckerman (1978, Ap.J.Lett., 225, L75) and Penzias (1979, Ap.J., 228, 430) investigated deuterated species in a number of different molecules.

The following molecules were analyzed for isotopic abundance ratios: HCO^+ (Langer et al. 1978, Ap.J.Lett., 225, L139; Guelin and Thaddeus 1979, Ap.J.Lett., 227, L139; Stark, 1981, Ap.J., 245, 99); HCN (Wannier et al. 1981, Ap.J., 247, 522); HCO^+ and HCN (Rydbeck et al. 1981, Ap.J.Lett., 243, L41); H_2CO (Gardner and Whiteoak, 1979, MNRAS, 188, 331 and 1981, 194, 37P; Tucker et al. 1979, Ap.J.Lett., 227, L143; Henkel et al. 1979, A&A, 73, L13 and 1980, 82, 41; Langer et al. 1979, Ap.J.Lett., 232, L169; Angerhofer et al. 1978, A.J., 83, 1417); CO (Langer et al. 1980, Ap.J.Lett., 235, L39; McCutcheon et al. 1980, Ap.J., 237, 9; Lada and Wilking 1980, Ap.J., 238, 620; Wilson et al. 1981, Ap.J.Lett., 243, L47; Crutcher and Watson, 1981, Ap.J., 244, 855; Huggins et al. 1981, Ap.J., 244, 863; Caldwell, 1979, A&A, 71, 255; White et al. 1980, A&A, 84, 212; Combes et al. 1980, A&A, 90, 88); HC_3N (Langer et al. 1980, Ap.J.Lett., 239, L125); CS (Frerking et al. 1980, Ap.J., 240, 65); CH^+ (Vanden Bout and Snell, 1980, Ap.J., 236, 460); NH_3 (Wilson and Pauls, 1979, A&A, 73, L10); HCN (Snell and Wooten, 1979, Ap.J., 228, 748); OH (Williams and Gardner, 1981, PASP, 93, 82); H_2 (Wright and Morton, 1979, Ap.J., 227, 483); NH_2CHO (Gardner et al. 1980, MNRAS, 193, 713); and SiO (Wolff, 1980, Ap.J., 242, 1005; Olofsson et al. 1981, A&A, 100, L30).

The fractionation of $^{13}C/^{12}C$ and $^{18}O/^{16}O$ in C^+, HCO^+ and CO and of $^{14}N/^{15}N$ in N_2H^+ and N_2 were investigated in the laboratory respectively by Smith and Adams (1980, Ap.J., 242, 424) and Adams and Smith (1981, Ap.J.Lett., 247, L123). The expected distribution of ^{13}C in HC_3N was calculated (Wolfsberg et al. 1979, A&A, 74, 369).

C. NEW TRANSITION FREQUENCIES

Frequencies of molecular transitions of astrophysical interest were either calculated or measured in the following papers: OH Λ-doubling in vibrationally excited states (Bekooy et al. 1978, Ap.J.Lett., 224, L77); CSiH and SiCH (Wilson, 1978, Ap.J., 224, 1077); NHD (Brown and Steimle, 1980, Ap.J.Lett., 236, L101); HNC (Frerking et al. 1979, Ap.J.Lett., 232, L65); H_2O in the excited ν_2 vibrational state (Kuze, 1980, Ap.J., 239, 1131); HC_4H (Buijs and Ramsay, 1980, Ap.J.Lett., 235, L115); C_2N, C_2N^+ and C_3H (Green, 1980, Ap.J., 240, 962); C_3H^+ and C_4H^+ (Wilson and Green, 1980, Ap.J., 240, 968); C_2H (Reitblat,1980, Soviet Astron. Lett., 6, 406); $HNCH^+$ (Dardi and Dykstra, 1980, Ap.J.Lett., 240, L171); CS^+ (Quarta and Singh, 1981, A&A, 98, 384); HCS^+ (Chekir et al. 1981, A&A, 100, L14); NH_2 (Charo et al. 1981, Ap.J.Lett., 244, L111); OH^+ (Singh and Almeida,1980, A&A, 84, 177); and CH_3OD (Kaushik and Takagi,1979, Publ. Astron. Soc. Japan 31, 423).

An extremely valuable compendium of observed interstellar and circumstellar microwave transitions was compiled by Lovas et al. (1979, Ap.J. Suppl., 41, 451).

D. INTERSTELLAR CHEMISTRY

The chemistry of interstellar clouds is believed to take place primarily in the gas phase (H_2 excepted). Ion-molecule reactions without activation energies probably dominate the chemistry of interstellar space but not of circumstellar envelopes which are discussed separately in § I below.

The chemistry of diffuse clouds has been investigated in the following papers: Smith and Parkinson (1978, Ap.J.Lett., 223, L127) measured oscillator strengths for H_2O. Smith and Snow searched for OH and H_2O (1979, Ap.J., 228, 435) and Field et al. considered the reaction $H+OH \rightarrow H_2O+h\nu$ (1980, MNRAS, 192, 1). Millar et al. investigated H_2CO production (1979, MNRAS, 186, 685). Qaiyum and Ansari considered chlorine chemistry (1979, MNRAS, 186, 621) and Kirby and Dalgarno (1978, Ap.J., 224, 444) considered LiH and NaH. Lutz et al. (1979, Ap.J., 227, 159) searched for N_2. Federman et al. analyzed the transition from H to H_2 (1979, Ap.J., 227, 466) and the H/H_2 ratio was determined in various directions by Liszt and Burton (1979, Ap.J., 228, 105), Liszt et al. (1981, Ap.J., 246, 74), Winnberg et al. (1980, A&A, 90, 176), Sato and Fukui (1978, A.J., 83, 1607), McCutcheon et al. (1978, MNRAS, 185, 755), Read (1980, MNRAS, 192, 11), Alferova et al. (1980, Soviet Astron. Lett., 6, 401), and Llewellyn et al. (1981, MNRAS, 196, 29P).

Models were constructed for the ζ Persei cloud (Black et al. 1978, Ap.J., 224, 448). Sandell (1978, A&A, 69, 85) considered the lifetimes of various molecules Liszt considered carbon abundances (1981, Ap.J.Lett., 246, L147) and Crutcher OH abundances (1979, Ap.J., 234, 881). Viala et al. (1979, A&A, 73, 174) computed chemical and thermal equilibrium states for clouds.

CH^+ was discussed by Cosby et al. (1980, Ap.J., 235, 52), Kirby et al. (1980, Ap.J., 239, 855), and Frisch and Jura (1980, Ap.J., 242, 560), OH^+ by Singh and Almeida (1981, A&A, 95, 383). Roberge et al. (1981, Ap.J., 243, 817) considered photoionization and photodissociation processes. Watson et al. (1978, A&A, 69, 159) analyzed $H^+ + D \rightarrow H + D^+$ and Bieniek and Dalgarno (1979, Ap.J., 228, 635), $H + H^- \rightarrow H_2 + e$. Molecular candidates for the diffuse bands were studied in the laboratory by Wdowiak (1980, Ap.J.Lett., 241, L55). Flower and Roueff (1979, A&A, 72, 361) discussed the formation and destruction of HeH^+ and Feibelman et al. searched for H_2^+ near planetary nebulae (1981, A.J., 86, 881).

In denser clouds molecule formation and destruction was studied by Langer (1978, Ap.J., 225, 860), McAllister (1978, Ap.J., 225, 857), Prasad and Huntress (1979, Ap.J., 228, 123 and 1980, 239, 151 and 1980, Ap.J. Suppl., 43, 1 and 1978, MNRAS, 185, 741), Green and Herbst (1979, Ap.J., 229, 121), Huntress and Mitchell (1979, Ap.J., 231, 456), Schiff and Bohme (1979, Ap.J., 232, 740), Mitchell et al. (1979, Ap.J., 233, 102 and 1978, Ap.J. Suppl., 38, 39), Viggiano et al. (1980, Ap.J., 236, 492), Herbst (1980, Ap.J., 237, 462 and 241, 197), Mul and McGowan (1980 Ap.J., 237, 749), Haese and Woods (1981, Ap.J.Lett., 246, L51), Henning (1981, A&A Suppl., 44, 405),Mitchell (1978, A.J., 83, 1612), Duley et al. (1980, MNRAS, 192, 945), Smith and Adams (1981, MNRAS, 197, 377), Reitblat (1980, Soviet Astron. Lett., 6, 281), and Bar-Nun et al. (1980, A&A, 87, 328). Ion-molecule reactions were studied in the laboratory by Freeman et al. (1979, MNRAS, 187, 441) and Smith et al. measured oscillator strengths for HCl (1980, Ap.J., 238, 874).

Wootten et al. (1979, Ap.J., 234, 876) and Umebayashi and Nakano (1980, Publ. Astron. Soc. Japan, 32, 405) considered ionisation in molecular clouds (e/H_2). Abundances in the denser clouds were measured for CO by Dickman (1978, Ap.J.Suppl., 37, 407) for various molecules by Wootten et al. (1978, Ap.J.Lett., 225, L143), and for HC_3N and HC_5N by Walmsley et al. (1980, A&A, 81, 245). Cesarsky and Volk discussed cosmic ray penetration into molecular clouds (1978, A&A, 70, 367).

Unsuccessful searches were made for various molecules including: $(CO)_2$ (Vanden Bout et al. 1979, Ap.J., 234, 503), pyrrole (Myers et al. 1980, Ap.J., 241, 155), glycine and molecules containing phosphorus (Hollis et al. 1980, Ap.J., 241, 158 and 1001), pyrrole and furan (Kutner et al. 1980, Ap.J., 242, 541), N_2O (Wilson

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and Snyder 1981, Ap.J., 246, 86), CaO (Hocking et al. 1979, A&A. 75, 268), imidazole and cyanoform (Irvine et al. 1981, A&A, 97, 192), TiO (Churchwell et al. 1980, A.J., 85, 1382), glycine (Brown et al. 1979, MNRAS, 186, 5P), and CH_3D (Pickett et al. 1980, Ap.J.Lett., 236, L43).

The chemistry in shocked regions of interstellar space was studied by Iglesias and Silk (1978, Ap.J., 226, 851), Làda et al. (1978, Ap.J.Lett., 226, L153), DeNoyer (1979, Ap.J.Lett., 228, L41 and 232, L165), DeNoyer and Frerking (1981, Ap.J.Lett., 246, L37), Elitzur (1980, A&A, 81, 351 and 1979, Ap.J., 229, 560), Dalgarno and Roberge (1979, Ap.J.Lett., 233, L25), Elitzur and Watson (1980, Ap.J., 236, 172), Hartquist et al. (1980, Ap.J., 236, 182), Dickinson et al. (1980, Ap.J.Lett., 237, L43), Hollenbach and McKee (1979, Ap.J. Suppl., 41, 555 and 1980, Ap.J.Lett., 241, L47), Federman (1980, Ap.J.Lett., 241, L109), Herbst and Knudson (1981, Ap.J., 245, 529), and Saito and Deguchi (1980, Publ. Astron. Soc. Japan, 32, 257).

E. MOLECULAR EXCITATION

Non-Maser Emission. Schwartz discusses estimating collisional rates from laboratory data (1979, Ap.J.Lett., 229, L45). Green and Truhlar calculated H_2-H collisional rates (1979, Ap.J.Lett., 231, L101) and Elitzur and Watson (1978, A&A, 70, 443) the cooling rates due to such collisions. Shull analyzed H_2 resonance fluorescence with Lyα (1978, Ap.J., 224, 841) and Black and Hartquist (1979, Ap.J.Lett., 232, L179) estimated H_2 emission from OH maser regions. Arshutkin and Kolesnik (1980, Astrofiz., 16, 737) propose a simple expression for the cooling of clouds by CO. Matsakis (1979, Ap.J., 234, 861) considered the 2.7K cosmic background radiation and H_2CO excitation. Koppen and Kegel (1980, A&A Suppl., 42, 59) calculate CO population inversions and Scoville et al. (1980, Ap.J., 240, 929) and Krotkov et al. (1980, Ap.J., 240, 940) collisional and infrared and ultraviolet pumping of CO. Carroll and Goldsmith (1981, Ap.J., 245, 891) analyzed infrared pumping of molecules. Varshalovich and Khersonskii (1978, Soviet Astron., 22, 667) analyzed the rotational level populations of CO, CS and SiO. Deguchi et al. (1979, Publ. Astron. Soc. Japan, 31, 105) carried out laboratory and theoretical investigations of the vibration excitation of HC_3N.

Bhattacharyya et al. (1981, Ap.J., 247, 936) and Dickinson and Flower (1981, MNRAS, 196, 297) consider the excitation of molecular ions and Flower (1979, A&A, 73, 237) the excitation of CH^+ and HeH^+, all by electron collisions. Green calculated collisional excitation rates for H_2O (1980, Ap.J.Suppl., 42, 103). Guilloteau and Baudry analyzed hyperfine intensity ratios in HCN (1981, A&A, 97, 213). Flower considered the rotational excitation of OH by H_2 (1980, A&A, 83, 33) and Bouloy and Omont collisional rates for inducing OH Λ-doublet transitions (1979, A&A Suppl., 38, 101). Dixon and Field (1979, MNRAS, 189, 583) calculate collisionally induced Λ-doublet population inversions in OH, OD, CH, CD, and NH^+.

F. MICROWAVE SURVEYS

Phillips et al. (1979, Ap.J., 231, 720) surveyed CO in the J = 2 →1 transition. CO(J=1→0) was observed by Szabo et al (1980, Ap.J., 235, 45) toward $\ell=30^\circ$, $b=0^\circ$, by Kutner et al. toward 130 reflection nebulae (1980, Ap.J., 237, 734), and by Bania in the inner Milky Way (1980, Ap.J., 242, 95). Liszt and Burton (1981, Ap.J., 243, 778) interpret galactic CO maps.

Churchwell (1980, Ap.J., 240, 811) surveyed CN. OCS was surveyed by Goldsmith and Linke (1981, Ap.J., 245, 482), H_2O by Genzel and Downes (1979, A&A, 72, 234), Batchelor et al. (1980, Austr. J. Phys., 33, 139), and Scalise and Braz (1980, A&A, 85, 149), H_2CO and CO by Scoville and Wannier (1979, A&A, 76, 140), H110α and H_2CO by Downes et al. (1980, A&A Suppl., 40, 379), H_2CO by Few (1979, MNRAS, 187, 161) and Goss et al. (1980, MNRAS, 191, 533), and H_2CS by Gardner et al. (1980, MNRAS, 191, 19P).

Turner (1979, A&A Suppl., 37, 1) carried out a massive OH survey and Gahm et

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al. (1980, A&A, 83, 263) an OH survey of Orion population stars. Baud et al. carried out 1612 MHz galactic plane and galactic center surveys (1981, A&A, 95, 156 and 171 and 1979, A&A Suppl., 35, 179) for OH masers. Mutel and Edgar surveyed at 1612 MHz at high declinations for OH masers (1979, PASP, 91, 422). Caswell et al. (1980, Austr. J. Phys., 33, 639) surveyed the southern galactic plane for OH.

G. CLOUD MORPHOLOGY, DYNAMICS, MAGNETIC FIELDS, AND EVOLUTION

We divide this section into observations of the galactic center region, general galactic clouds, and relatively local diffuse and dust (i.e., Lynds-type) clouds, and theory. Large scale surveys are given in the preceding section.

1. Galactic Center Region. The following molecules were observed: CO (Liszt and Burton, 1979, Ap.J., 226, 790; Zuckerman and Kuiper, 1980, Ap.J., 235, 840), HC_5N (Avery et al. 1979, Ap.J., 231, 48), HCO^+ (Fukui et al. 1980, Ap.J., 241, 147; Linke et al. 1981, Ap.J., 243, 147), NH_3 (Winnewisser et al. 1979, A&A, 72, 215), and H_2CO (Gusten and Downes, 1980, A&A, 87, 6 and 1981, 99, 27; Bieging et al. 1980, A&A Suppl., 42, 163; Whiteoak and Gardner, 1979, MNRAS, 188, 445; Cohen and Few, 1981, MNRAS, 194, 711).

2. Galactic Clouds. Orion was studied in the microwave portion of the spectrum by: Ho and Barrett (1978, Ap.J.Lett., 224, L23); Sweitzer and Sweitzer et al. (1978, Ap.J., 225, 116 and 1979, 227, 415), Evans et al. (1979, Ap.J.Lett., 227, L25), Jennings and Fox (1979, Ap.J., 227, 433), Huggins et al. (1979, Ap.J., 227, 441), Pickett and Davis (1979, Ap.J., 227, 446), Clark et al. (1979, Ap.J., 229, 553 and 234, 922), Ho et al. (1979, Ap.J., 234, 912), Loren and Loren et al. (1979, Ap.J.Lett., 234, L207 and 1981, 244, L107), Waters et al. (1980, Ap.J., 235, 57), Morris et al. (1980, Ap.J., 237, 1), Myers and Buxton (1980, Ap.J., 239, 515), Goldsmith et al. (1980, Ap.J., 240, 524), Ellder et al. (1980, Ap.J.Lett., 242, L93), Rydbeck et al. (1981, Ap.J.Lett., 243, L41), Goldsmith et al. (1981, Ap.J.Lett., 243, L79), Solomon et al. (1981, Ap.J.Lett., 245, L19), Welch et al. (1981, Ap.J. Lett., 245, L87), Wilson et al. (1979, A&A, 71, 275), Baud and Wouterloot (1980, A&A, 90, 297), Gillespie and White (1980, A&A, 91, 257), Bastien et al. (1980, A&A, 98, L4), van Vliet et al. (1981, A&A, 101, L1), Padman et al. (1980, MNRAS, 192, 87P) and Nagai et al. (1979, Publ. Astron. Soc. Japan, 31, 317), and in the infrared by: Young and Knacke (1978, Ap.J., 224, 848 and 1980, 242, L183), Beckwith et al. (1979, Ap.J., 227, 436), Nadeau and Geballe (1979, Ap.J.Lett., 230, L169), Simon et al. (1979, Ap.J.Lett., 230, L175), Scoville et al. (1979, Ap.J.Lett., 232, L121), Beck et al. (1979, Ap.J.Lett., 234, L213), Watson et al. (1980, Ap.J.Lett., 239, L129), Downes et al. (1981, Ap.J., 244, 869), and Storey et al. (1981, Ap.J., 247, 136).

Other regions that were investigated included: W75-DR21 (Dickel et al. 1978, Ap.J., 223, 840), IC 1848A (Loren and Wooten, 1978, Ap.J.Lett., 225, L81), globular clusters (Schneps et al. 1978, Ap.J., 225, 808), W3, W4, and W5 (Lada et al. 1978, Ap.J.Lett., 226, L39 and Goudis and White 1980, A&A, 83, 79), W3 (Dickel et al. 1980, Ap.J., 237, 711; Dickel, 1980, Ap.J., 238, 829; Brackmann and Scoville, 1980, Ap.J., 242, 112), NGC 7129 (Bechis et al. 1978, Ap.J., 226, 439), NGC 2264 (Crutcher et al. 1978, Ap.J., 226, 839; Lang and Wilson 1980, Ap.J., 238, 867; Minn and Greenberg 1979, A&A, 77, 37; Greenberg et al. 1979, A&A, 78, 100), NGC 281 (Elmegreen and Moran 1979, Ap.J.Lett., 227, L93), M17 (Elmegreen et al. 1979, Ap.J., 230, 415), NGC 2175 (Lada and Wooden, 1979, Ap.J., 232, 158), W51 (Mufson and Liszt, 1979, Ap.J., 232, 451), Mon R1 (Kutner et al. 1979, Ap.J., 232, 724), Mon R2 (Willson and Folch-Pi, 1981, A.J., 86, 1084 and White et al. 1979, MNRAS, 186, 107), Ceph OB3 and Per OB2 (Sargent, 1979, Ap.J., 233, 163), Ceph A (Rodriguez et al. 1980, Ap.J.Lett., 240, L149 and Brown et al. 1981, MNRAS, 195, 607), Ceph B (Panagia and Thum, 1981, A&A, 98, 295), IC 443 (Treffers, 1979, Ap.J.Lett., 233, L17), S255 (Schloerb and Scoville, 1980, Ap.J.Lett., 235, L33), S147 (Gondhalekar and Phillips, 1980, MNRAS, 191, 13P), W58 (Israel. 1980. Ap.J.. 236. 465). V645 Cyg (Harvey and Lada, 1980, Ap.J., 237, 61 and Rodriguez et al. 1981, A.J., 86,

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1245), W80 (Bally and Scoville, 1980, Ap.J., 239, 121), The Rosette Nebula (Schneps et al. 1980, Ap.J., 240, 84; Blitz and Thaddeus, 1980, Ap.J., 241, 676), CMa OB1/R1 (Machnik et al. 1980, Ap.J., 242, 121), NGC 2359 (Schneps et al. Ap.J., 243, 184), NGC 2261 and R Mon (Canto et al. 1981, Ap.J., 244, 102), GL 490 (Lada and Harvey, 1981, Ap.J., 245, 58), W28 (Wootten, 1981, Ap.J., 245, 105), Cas A (Encrenaz et al. 1980, A&A, 88, L1), S235 (Evans and Blair, 1981, Ap.J., 246, 394), IC 5146 (Lada and Elmegreen, 1979, A.J., 84, 336), IRC +10442 (Bally et al. 1980, A.J., 85, 1242), Lk H 208 (Good et al. 1981, A.J., 86, 892), S106 (Little et al., 1979, MNRAS, 188, 429), NGC 2024 (Watt et al. 1979, MNRAS, 189, 287), NGC 2068 and 2071 (White and Phillips, 1981, MNRAS, 194, 947), W48 (Paschenko et al. 1979, Soviet Astron. Lett., 5, 326), W33 (Paschenko, 1980, Soviet Astron. Lett., 6, 58), and 3C 123 (Crutcher, 1980, Ap.J., 239, 549).

The following molecules were observed in a number of sources: CN (Allen and Knapp, 1978, Ap.J., 225, 843), NH_3 (Schwartz et al. 1978, Ap.J., 226, 469; Matsakis et al. 1980, Ap.J., 241, 655, Little et al. 1980, MNRAS, 193, 115; Macdonald et al. 1981, MNRAS, 195, 387), HC_3N (Wannier and Linke, 1978, Ap.J., 226, 817), CH_3OH (Gottlieb et al. 1979, Ap.J., 227, 422), $HCOOCH_3$ (Churchwell et al. 1980, Ap.J.Lett., 241, L169), SO (Rydbeck et al. 1980, Ap.J.Lett., 235, L171), H_2 (Fischer et al. 1980, Ap.J.Lett., 238, L155 and 240, L95 and Scoville et al. 1979, A.J., 84, 1571), HCO^+ (Loren and Wootten,1980, Ap.J., 242, 568 and Batchelor et al. 1981, MNRAS, 194, 911), CO (Myers, 1980, Ap.J., 242, 1013; Loren et al. 1981, Ap.J., 245, 495; Phillips et al. 1981, Ap.J., 245, 512; Fischer et al. 1979, A.J., 84, 1574; Israel, 1980, A.J., 85, 1612; Gillespie et al. 1979, MNRAS, 186, 383), H_2CO (Wilson and Jaffe, 1981, Ap.J., 245, 866 and Wilson et al. 1980, A&A, 91, 36), SiS (Dickinson and Kuiper, 1981, Ap.J., 247, 112), CO and H_2CO (Nachman, 1979, Ap.J. Suppl., 39, 103), CH (Genzel et al. 1979, A&A, 73, 253 and Sandell et al. 1980, A&A, 83, 226), HCO^+, HCN, HNC, and C_2H (Baudry et al. 1980, A&A, 85, 244), OH (Storey et al. 1981, Ap.J.Lett., 244, L27, Pashchenko and Rudnitskii, 1979, Soviet Astron., 23, 629 and 1980, 24, 695), HCN, CO and CH (Dinger et al. 1979, PASP, 91, 830), and HCN (Whiteoak and Gardner, 1978, MNRAS, 185, 33P).

The properties and/or evolution of a "typical" cloud averaged over the galaxy (or a portion of it), were derived by: Stark and Blitz (1978, Ap.J.Lett., 225, L15), Myers (1978, Ap.J., 225, 380), Plambeck and Williams (1979, Ap.J.Lett., 227, L43), Solomon et al. (1979, Ap.J.Lett., 232, L89), Linke and Goldsmith (1980, Ap.J., 235, 437), Evans et al. (1980, Ap.J., 239, 839), Wootten et al. (1980, Ap.J., 240, 532), Ho et al. (1981, Ap.J., 246, 761) and Israel (1978, A&A, 70, 769).

Magnetic fields were searched for by Clark et al. (1978, Ap.J., 226, 824) and Brown et al. (1980, MNRAS, 190, 1).

3. Local Dust Clouds. Molecules were observed in the following directions: χ Oph (Frisch, 1979, Ap.J., 227, 474 and 1980, 241, 697), Cr A (Loren, 1979, Ap.J., 227, 832), ζ Oph (Crutcher, 1979, Ap.J.Lett., 231, L151; Liszt, 1979, Ap.J.Lett., 233, L147), ζ Per (Hobbs, 1979, Ap.J.Lett., 232, L175; Chaffee et al. 1980, Ap.J., 236, 474), Heiles Cloud 2, also called Taurus Molecular Cloud I (MacLeod et al. 1979, Ap.J., 233, 584; Myers et al. 1979, Ap.J.Lett., 233, L141; Friberg et al. 1980, Ap.J.Lett., 241, L99; Baud and Wouterloot, 1980, A&A, 90, 297; Tolle et al. 1981, A&A, 95, 143; Henkel et al. 1981, A&A, 99, 270; Sherwood and Wilson, 1981, A&A, 100, 72; Gardner and Winnewisser, 1978, MNRAS, 185, 57P; Little et al. 1979, MNRAS, 189, 539), L134 (Dickman et al. 1979, Ap.J., 234, 100 and 1980, 238, 853; Clark and Johnson, 1981, Ap.J., 247, 104; Mattila et al. 1979, A&A, 78, 275; Ungerechts et al. 1980, A&A, 88, 259), L1551 (Snell et al. 1980, Ap.J.Lett., 239, L17; Beichman and Harris 1981, Ap.J., 245, 589), ρ Oph (Loren et al. 1980, Ap.J. Lett., 240, L165; Javanaud 1979, MNRAS, 188, 203 and 1980, 190, 487), o Per (Hobbs, 1981, Ap.J., 243, 485), L1778/80 (Mattila and Sandell, 1979, A&A, 78, 264), L1642 (Sandell et al. 1981, A&A, 97, 317), L1641 (Few and Booth, 1979, MNRAS, 188, 181), L43 (Elmegreen and Elmegreen 1979, A.J., 84, 615), and HD 154368 (Blades,1978,

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MNRAS, 185, 451).

Observations of molecules were made in the following types of clouds: Diffuse and dark clouds (Lang and Wilson, 1978, Ap.J., 224, 125; Wootten et al. 1980, Ap.J., 239, 844; Federman et al. 1980, Ap.J., 242, 545; Benson and Myers, 1980, Ap.J.Lett., 242, L87; Snell, 1981, Ap.J. Suppl., 45, 121; Sandquist and Bernes, 1980, A&A, 89. 187; Dickey et al. 1981, A&A, 98, 271; Phillips and White, 1981, MNRAS, 194, 15); toward bright stars (Willson, 1981, Ap.J., 247, 116 and Cosmovici and Strafella, 1981, A&A, 98, 408); clouds containing Herbig-Haro objects (see Section 6 for references), and toward young stars (Lang and Willson, 1979, Ap.J., 227, 163 and Loren 1981, A.J., 86, 69).

The long carbon chain molecules (HC_nN) were observed in a variety of clouds by Bujarrabal et al. (1981, A&A, 99, 239), Snell et al. (1981, Ap.J., 244, 45) and Rodriguez and Chaisson (1980, MNRAS, 192, 651). Federman and Glassgold (1980, A&A, 89, 113) modeled the cloud toward γ Arae. Reif et al. searched for the Zeeman effect in the 21-cm line in L134, L1016 and B152 (1978, A&A, 70, 271).

4. Theory. The kinds of problems that were investigated include: cloud conditions, kinematics and collapse; the formation and lifetimes of molecular clouds and their interactions with H II regions. References are given in Sections 2 and 6 of this report. Magnetic fields in molecular clouds are dealt with by: Langer (1978, Ap.J., 225, 95), Elmegreen (1979, Ap.J., 232, 729), Garlick (1979, A&A, 73, 337), Baker (1979, A&A, 75, 54), Hartquist et al. (1979, A&A, 75, 137), Morfill and Stenholm (1980, A&A, 90, 134), Elmegreen (1978, Ap.J.Lett., 225, L85) and Hartquist (1980, MNRAS, 191, 49).

H. MASERS

1. Interstellar and Protostellar. Positions, properties, and distributions of masers were determined: for H_2O and OH by Mader et al. (1978, Ap.J., 224, 115); for H_2O by Walker et al. (1978, Ap.J., 226, 95), Rodriguez et al. (1978, Ap.J., 226, 115), Blair et al. (1978, Ap.J., 226, 435; 1980, A.J., 85, 161), Blitz and Lada (1979, Ap.J., 227, 152), Dieter et al. (1979, Ap.J., 230, 768), Moran and Rodriguez (1980, Ap.J.Lett., 236, L159), Haschick et al (1980, Ap.J., 237, 26), Elmegreen et al. (1980, Ap.J., 241, 1007), Lada et al. (1981, Ap.J., 243, 769), Genzel et al. (1981, Ap.J., 244, 884 and 247, 1039 and 1979, A&A, 78, 239), Cesarsky et al. (1978, A&A, 68, 33), Downes et al. (1979, A&A, 79, 233), Bettweiser et al. (1981, A&A, 93, 8), Sandell and Olofsson (1981, A&A, 99, 80), Cohen and Malkan (1979, A.J., 84, 74), Dinger and Dickinson (1980, A.J., 85, 1247), Walker (1981, A.J., 86, 1323), Cohen (1979, Ap. Lett., 20, 81), and Garcia-Barreto et al. (1981, Rev. Mex. Astron. Astrofiz., 5, 87); for OH by Evans et al. (1979, Ap.J., 227, 450), Reid et al. (1980, Ap.J., 239, 89), Haschick et al. (1981, Ap.J., 244, 76), Cesarsky and Little (1979, A&A, 80, L1), Cohen and Willson (1981, A&A, 96, 230), Dickey and Malkan (1980, A.J., 85, 145), Winnberg et al. (1981, A.J., 86, 410), Norris et al. (1980, MNRAS, 190, 163), Norris and Booth (1981, MNRAS, 195, 213). Davis et al. (1979, Ap.J., 230, 434) looked for OH from early-type stars and Anderson et al. at OH in V1057 Cyg (1979, A&A, 80, 260). Others looked for: H_2CO in NGC 7538 (Rots et al. 1981, Ap.J.Lett., 245, L15; Forster et al. 1980, A&A, 84, L1; Boland and de Jong, A&A, 98, 149), SiO in Orion (Genzel et al. 1979, Ap.J.Lett., 231, L73 and 1980, 239, 519, and Hjalmarson and Olofsson, 1979, Ap.J.Lett., 234, L199), and CH_3OH in Orion (Matsakis et al. 1980, Ap.J., 236, 481).

Magnetic fields were investigated via the Zeeman effect in OH by Moran et al. (1978, Ap.J.Lett., 224, L67) and Wouterloot et al. (1980, A&A, 81, L11). Time variations were studied in H_2O by Burke et al. (1978, Ap.J.Lett., 226, L21), White (1979, MNRAS, 186, 377), White and Macdonald (1979, MNRAS, 188, 745), Abraham et al. (1981, A&A, 100, L10) and Matveenko et al. (1980, Soviet Astron. Lett., 6, 279) and in OH by Cimerman (1979, Ap.J.Lett., 228, L79).

Theoretical analysis of maser phenomena was carried out by: Norman and Silk (1979, Ap.J., 228, 197), Elmegreen and Morris (1979, Ap.J., 229, 593), Kaplan and Shapiro (1979, Ap.J.Lett., 229, L91), Bettwieser (1979, A&A, 72, 97 and 1981, 93, 8), Elitzur (1979, A&A, 73, 322 and 1980, 81, 354), Hartquist (1979, A&A, 77, 361), Burdjuzha (1979, A&A, 79, 306), Bujarrabal et al. (1980, A&A, 81, 1), Lucas (1980, A&A, 84, 36), Guilloteau et al. (1981, A&A, 97, 347), Kegel (1979, A&A Suppl., 38, 131), Burdjuzha (1978, Soviet Astron. Lett., 4, 298) and Strelnitskii (1980, Soviet Astron. Lett., 6, 196).

2. Circumstellar. The following papers all deal with post main-sequence stellar masers. SiO masers were studied by Snyder et al. (1978, Ap.J., 224, 512), Lepine et al. (1978, Ap.J., 225, 869), Zuckerman (1979, Ap.J., 230, 442), Moran et al. (1979, Ap.J.Lett., 231, L67), Troland et al. (1979, Ap.J., 232, 143), Hjalmarson and Olofsson (1979, Ap.J.Lett., 234, L199), Clark et al. (1981, Ap.J.Lett., 244, L99), Olofsson et al. (1981, Ap.J.Lett., 247, L81), Schwartz et al. (1979, A.J., 84, 1349) and Spencer et al. (1981, A.J., 86, 392).

OH masers were studied by Reid et al. (1979, Ap.J.Lett., 227, L89 and 1981, A.J., 86, 897), Mutel et al. (1979, Ap.J., 228, 771), Benson et al. (1979, Ap.J. Lett., 229, L87), Davis et al. (1979, Ap.J., 230, 434), Fix (1979, Ap.J.Lett., 232, L39), Benson and Mutel (1979, Ap.J., 233, 119), Cimerman (1979, Ap.J., 234, 891), Fix et al. (1980, Ap.J.Lett., 241, L95), Jewell et al. (1980, Ap.J.Lett., 242, L29 and 1979, Ap.J. Suppl., 41, 191), Bowers et al. (1980, Ap.J., 242, 1088), Olnon et al. (1981, Ap.J.Lett., 245, L103), LeSqueren et al. (1979, A&A, 72, 39), Nguyen-Q-Rieu et al. (1979, A&A, 75, 1), Mennessier (1981, A&A, 93, 333), Silverglate et al. (1979, A.J., 84, 345), Morris and Bowers (1980, A.J., 85, 724), Winnberg et al. (1981, A.J., 86, 410), Brocka (1979, PASP, 91, 519), Norris et al. (1980, MNRAS, 190, 163), and Allen et al. (1980, MNRAS, 192, 505).

OH and H_2O masers were studied by Olnon et al. (1980, A&A Suppl. 42, 119). H_2O, SiO and OH masers were searched for in symbiotic stars by Cohen and Ghigo (1980, A.J., 85, 451). H_2O masers were studied by Spencer et al. (1979, Ap.J., 230, 449), Kleinmann et al. (1978, A.J., 83, 1206), Dos Santos et al. (1979, A.J., 84, 787), Blair et al. (1980, A.J., 85, 161), Hagen (1979, PASP, 91, 165), and Cox and Parker (1979, MNRAS, 186, 197). Scharlach and Woolf (1979, PASP, 91, 380) found no correlation of maser activity with Hδ emission in long period variable stars.

Theoretical considerations pertinent to circumstellar masers are contained in papers by: Van Blerkom (1978, Ap.J., 223, 835), Michalitsianos and Kafatos (1978, Ap.J., 226, 430), Cahn and Elitzur (1979, Ap.J., 231, 124). Cimerman and Scoville (1980, Ap.J., 239, 526), Watson et al. (1980, Ap.J., 240, 547), Elitzur (1980, Ap.J., 240, 553), Bujarrabal et al. (1980, A&A, 81, 1 and 84, 311), Epchtein et al. (1980, A&A, 85, L1), Zhen-pu (1981, Chinese Astron. Astrophys., 5, 139), and Ying and Jin (1981, Chinese Astron. Astrophys., 5, 183).

I. CIRCUMSTELLAR (NON-MASER)

With increasing sensitivity in the millimeter and infrared spectral regions it is rapidly becoming more feasible to study non-maser emission (and absorption) from circumstellar envelopes around late-type giant stars. Microwave emission from SiO has been studied by Morris et al. (1979, Ap.J., 229, 257), from CO by Wannier et al. (1979, Ap.J., 230, 149), Knapp et al. (1979, Ap.J., 233, 140 and 1980, 242, L25) and Zuckerman (1981, A.J., 86, 84), and from other molecules by Cummins et al. (1980, Ap.J., 235, 886), Kwok et al. (1981, Ap.J., 247, 125), Winnewisser and Walmsley (1978, A&A, 70, L37), and Grasshoff et al. (1981, A&A, 101, 238). Infared observations are due to Betz et al. (1979, Ap.J.Lett., 229, L97), Geballe et al. (1979, Ap.J.Lett., 230, L47), Krassner et al. (1979, Ap.J.Lett., 231, L31), Bernat et al. (1979, Ap.J.Lett., 233, L135), McLaren and Betz (1980, Ap.J.Lett., 240, L159), Smith et al. (1981, Ap.J., 244, 835), and Beckwith et al. (1980, A.J., 82,

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886). UV observations were carried out by Tarafdar et al. (1980, MNRAS, 192, 417) and Tarafdar and Krishna Swamy (1981, MNRAS, 196, 67). Schmidt et al. reported optical molecular emission from the "Red Rectangle" (1980, Ap.J.Lett., 239, L133). Zuckerman et al. searched for H I in (molecular) circumstellar envelopes (1980, Ap.J., 241, 1014).

Theoretical analysis of the physical and chemical state of the environment is presented in the following papers: Cahn and Wyatt (1978, Ap.J.Lett., 224, L79), Morris (1980, Ap.J., 236, 823), Scalo and Slavsky (1980, Ap.J.Lett., 239, L73), Clegg and Wootten (1980, Ap.J., 240, 828), and Clegg (1980, MNRAS, 191, 451).

J. EXTRAGALACTIC MOLECULES

A field that should grow rapidly during the next few years is the study of extragalactic molecules at millimeter wavelengths. Various molecules have been observed at microwave frequencies in external galaxies. These include: CO (Morris and Lo, 1978, Ap.J., 223, 803; Knapp et al. 1980, Ap.J., 240, 60; Elmegreen et al. 1980, Ap.J., 240, 455; Bieging et al. 1981, Ap.J., 247, 443; Encrenaz et al. 1979, A&A, 78, L1; Wilson et al. 1979, A&A, 79, 245; Rowan-Robinson et al. 1980, A&A, 82, 381; Boulanger et al. 1981, A&A, 93, L1), HCO^+ and HCN (Stark and Wolff, 1979, Ap.J., 229, 118), HCO^+ (Rickard and Palmer, 1981, Ap.J., 243, 765), H_2CO (Graham et al. 1978, A&A, 70, L69; Gardner and Whiteoak, 1979, MNRAS, 189, 51P), H_2O (Huchtmeier et al. 1980, A&A, 91, 259), OH (Caswell and Haynes, 1981, MNRAS, 194, 33P), and CH (Whiteoak et al. 1980, MNRAS, 190, 17P).

Varshalovich and Levshakov have observed H_2 and CO absorption lines in the spectra of quasars (1979, Soviet Astron. Lett., 5, 199 and 1979, Ap.Lett., 20, 67). Zinchenko (1979, Soviet Astron. Lett., 5, 233) and Khersonskii et al. (1981, Soviet Astron., 25, 16) have considered the observational effects of dust and molecules at cosmological distances.

5. Interstellar Grains

(B. Donn)

Books and proceedings of meetings are listed in the introduction to the Commission 34 Report. Reviews on various aspects of grains are also listed there. Much relevant information on grain formation and properties appears in the chemistry and physics literature. Of particular interest are the Proceedings of the 2nd International Meeting "Small Particles and Inorganic Clusters" which appear in Surface Science 106, 1981.

The average interstellar extinction curve is reviewed by Savage and Mathis. Regional variations in the visible (Lucke, 1980, A&A, 90, 350) show little correlation with galactic longitude except for Cygnus. Whittet (1979, A&A, 72, 370) reconsidered the longitude dependence of extinction and polarization. An extinction curve from 1-20 μm is given by Becklin et al. (1978, Ap.J., 220, 831). They concluded the ratio $E(v)/E_{9.7}$(silicate) = 8 $\pm$ 3 and the extinction within 3 kpc of the galactic center is not more than 6 mag. Two dark clouds yielded values of R = 4.2 (Chini et al. 1980, A&A, 91, 186; Chini, 1981, A&A, 99, 346).

Variable UV extinction in the galactic plane is reported by Kester (1981, A&A, 99, 375). In the Carina Nebula (The et al. 1980, A&A, 89, 209; 91, 360; Turner and Moffat, 1980, MNRAS, 192, 283) any deviation from normal is small. Ultraviolet extinction toward the Crab Nebula is obtained by Wu (1981, Ap.J., 245, 581). For dark clouds, results by Morales et al. (1980, A&A, 85, 302), Wu et al. (1980, Ap.J., 241, 173), Snow and Seab (1980, Ap.J.Lett., 242, L83), Witt et al. (1981, Ap.J., 244, 199), Seab et al. (1981, Ap.J., 246, 788) all show an anomalously small λ2200 bump. Anomalous extinction around Be stars is found by Sitko et al. (1981,

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Ap.J., 246, 161; 237, 82). The latter presents a detailed study of the envelope. The variability of the far UV rise confirms its independence and that of the λ2200 bump. Grains in the planetary, Abell 30 have a peak at λ2470 similar to amorphous carbon (Greenstein, 1981, Ap.J., 245, 124). UV extinction in OB-associations was measured by Morales et al. (1980, A&A Suppl., 42, 155). The Magellanic Clouds show a higher far-UV extinction (Nandy et al. 1980, Nature, 283, 725; Rocca-Volmerange et al. 1981, A&A, 99, L5; Koorneef and Mathis, Ap.J., 245, 49; Koorneef and Code, 1981, Ap.J., 247, 860). The last two papers report a weak λ2200 bump. Very broad-band structure, possibly due to magnetite was found by van Breda and Whittet (1981, MNRAS, 195, 79). Extinction towards CI Cyg is reported in Mikolajewska and Mikolajewski (1980, Acta Astron., 30, 347).

IS continuum absorption in the Galaxy has been studied by Kalandadze and Kolesnik (21.155.027), Bartkus (22.131.085), Kurchakov (22.131.176), Pavlova and Vil'koviskij (22.131.177), Sapar and Kuuzik (22.131.220), Dubyago (26.131.024), Kuuzik and Sapar (27.131.037), Slutskij et al. (1980, Pis'ma Astron.Zh., 6, 750), Strajzhis and Mejshtas (1980, Astr. Circ., USSR, N 1121), Nurmanova (1981, Astr. Circ., USSR, N 1155). (The numbers in parentheses refer to A&A Abstracts)

Interstellar grain distribution was studied in several regions: solar vicinity (Knude, 1979, A&A, 71, 344; 77, 198); within 3 kpc (Neckel and Klare, 1980, A&A Suppl., 42, 251); toward the South Galactic Pole (Albrecht and Maitzen, 1980, A&A Suppl., 42, 9); inner Galaxy (Maihara et al. 1981, A&A, 97, 139); large Z (Seki, 1978, Sci. Rep. Tohoku U. T, 266, 200).

Observations are interpreted to yield grains with different properties: high albedo, isotropic or low albedo, forward scattering (Witt and Cottrell, 1980, Ap.J., 235, 899; Witt, 1979, Astrophys. Space Sci., 65, 21); possibly isotropic (Jura, 1979, Ap.J., 231, 732); moderate forward throwing and low albedo (Morgan, 1980, MNRAS, 190, 825); moderate to low albedo (Jenkins and Shaya, 1979, Ap.J., 231, 55); high albedo, strong forward scatterers (Henry, 1981, Ap.J.Lett., 244, L69). Duley and Williams (1980, Ap.J.Lett., 242, L179) propose H_2 fluorescence is responsible for the high UV grain albedo in cloud regions. Polarization and scattering are examined in detail by White (1979, Ap.J., 229, 954; 230, 116; 241, 208). Model calculations for reflection nebulae in far UV are given by Shah and Krishna Swamy (1978, Kodaikanal Obs. Bull. A 2, 95).

Progress in Mie Theory calculations are described by Grehan and Gouesbet (1979, Appl. Opt., 18, 3489). New calculations for spheroidal particles are given by Asano (1979, Appl. Opt., 18, 712) and Onaka (1980, Ann. Tokyo Astron. Obs., 18, 1) and for graphite grains by Hecht (1981, Ap.J., 246, 794). Optics of amorphous particles are treated by Onaka et al. (1979, Astrophys. Space Sci., 65, 259) and Seki and Yamamato (1980, Astrophys. Space Sci., 72, 79). Porous graphite was studied by Blanco et al. (1980, Astrophys. Space Sci., 68, 505) and irregular, absorbing particles by Chiapetta (1980, A&A, 83, 348) . Effects of multiple grain components were studied by Sarazin (1978, Ap.J., 220, 165).

The extinction and possible discrete features of silicate and oxide grains were treated by Duley (1980, Ap.J., 240, 950; 1981, "Interstellar Molecules", p.281). Grain molecules as sources of infrared features were proposed by Allamandola et al. (1979, A&A, 77, 66; 1981, "Interstellar Molecules", p. 373) and Duley and Williams (1981, MNRAS, 196, 269).

Microwave analogue investigations of optical scattering by non-spherical, including very irregular particles are reported by Gustafson (1980, Rep. Obs. Lund No. 17), Scheurman et al. (1981, Appl. Opt., in press), and Giese (1980, "Solid Particles in Solar System", p. 1). Infrared spectra of a variety of silicates were reported by Rose (1979, Astrophys. Space Sci., 65, 47), Day (1979, Ap.J., 234, 158; 246, 110), Kratschmer and Huffman (1979, Astrophys. Space Sci., 61, 195), Stephens and Russell (1979, Ap.J., 228, 780), Dorschner et al. (1980, Astrophys. Space Sci., 68, 159), Kratschmer (1980, "Solid Particles in the Solar System", p. 351) and Koike et al. (1981, Astrophys. Space Sci., 79, 77), and Knacke and Kratschmer (1980, A&A, 92, 281) who also discuss carbon compounds. Stephens (1980, Ap.J., 237, 450) studied the visible and UV spectra of silicate, carbon and SiC smokes. Fraundorf et al. (1980, Nature, 281, 866) investigated the spectra of interplanetary dust.

The 3.1 μm absorption by amorphous water ice showing good agreement with the astronomical feature was measured by Leger et al. (1979, A&A, 79, 256) and Hagen et al. (1981, Chem. Phys., 56, 367). Irradiation of ice mixtures is being studied at Leiden using ultraviolet light (Greenberg, 1979, "Stars and Star Systems", ed. Westerlund, D. Reidel, p. 173; Hagen et al. 1979, Astrophys. Space Sci., 65, 215; 1980, A&A, 86, L3) and at NASA/Goddard with 1 MeV protons (Donn, 1981, "Comets and the Origin of Life", ed. Ponnamperuma, D. Reidel, p. 21; Moore, Thesis, University of Maryland). The formation of grains is studied at NASA/Goddard (Donn et al. 1981, Surface Sci., 106, 516; Khanna et al. 1981, J. Chem. Phys., 74, 2108).

Polarization observations: grains associated with stars, Hough et al. (1981, MNRAS, 195, 429), Tinbergen et al. (1981, A&A, 95, 215); star cluster, Coyne et al. (1979, A.J., 84, 356); M17, Schulz et al. (1981, A&A, 95, 94); nebulae, King et al. (1981, MNRAS, 196, 45), Tokunaga et al. (1981, A&A, 99, 108), Johnson et al. (1981, Ap.J., 245, 871); protostellar source GL2591, (Dyck and Lonsdale, 1980, A.J., 85, 1077); RCB cloud, Vrba et al. (1981, Ap.J., 243, 489); the Red Rectangle in Orion, Perkins et al. (1981, MNRAS, 196, 635); M31, Martin and Shawl (1979, Ap.J.Lett., 231, L57). Models for polarization were calculated by White (1979, Ap.J., 230, 116), Thronson (1979, A&A, 75, 236) and Svatos (1979, Bull. Ast. Inst. Czech, 31, 302). Mechanisms were examined by: Duley (1978, Ap.J.Lett., 219, L129), Srnka and De (1978, Ap.J., 225, 422), Purcell (1979, Ap.J., 231, 404) and Spitzer and McGlynn (1979, Ap.J., 231, 417). Circular polarization measurements were made by Michalsky and Schuster (1979, Ap.J., 231, 73) and Lonsdale et al. (1980, Ap.J.Lett., 238, L31).

Grain temperatures based on infrared observations are given by Dorschner et al. (1978, Astrophys. Space Sci., 54, 181), Gurtler et al. (1979, Astron. Nach., 300, 17) and Muizon et al. (1980, A&A, 83, 140). Relation between temperature and argon depletion is examined by Duley (1980, MNRAS, 190, 683). Small oxide grain temperatures are calculated by Millar (1981, Astrophys. Space Sci., 78, 505). The penetration and attenuation of ultraviolet radiation and their consequences for dense clouds have been studied by Arshutkin (1979, Astrometr. Astrofiz., 39, 27), Petrosian and Dana (1980, Ap.J., 241, 1094), Flannery et al. (1980, Ap.J., 236, 598) and Roberge et al. (1981, Ap.J., 243, 817). Scattered and transmitted intensities are calculated by Brand (1979, A&A, 71, 47). Grain temperature distributions and emergent fluxes for a symmetric cloud with a central star are calculated by Haisch (1979, A&A, 72, 161) and Rowan-Robinson (1980, Ap.J.Suppl., 44, 403). Polarization by a dust shell is calculated by Daniel (1980, A&A, 87, 204).

Hong and Greenberg (1980, A&A, 88, 194) made a detailed comparison of the bimodel size distribution with three components, ice coated large grains, small uncoated bare silicates and slightly larger graphites. They conclude that the extinction and polarization can be matched, with an enhanced Davis-Greenstein alignment mechanism. Mathis (1979, Ap.J., 232, 747) and Mathis and Wallenhorst (1981, Ap.J., 244, 483) conclude that a variety of three component, dielectric and conducting, uncoated particles of a unimodel distribution are satisfactory. Breger (1979, Ap.J., 233, 97) found no deviation from the standard IR excess-polarization relation. McCall (1981, MNRAS, 194, 485) concluded that smaller grains are destroyed inside the Orion Nebula. Carty et al. (1979, MNRAS, 189, 299) determined sizes in Eta Carinae. The origin of size distributions was studied by Biermann and Harwit (1980, Ap.J.Lett., 240, L105) using macroscopic fragmentation results. Duley and

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colleagues have proposed diatomic oxide grains: (1978, MNRAS, 183, 177; 1980, MNRAS, 191, 641; 1980, Ap.J.Lett., 240, L47; 1979, Astrophys. Space Sci., 61, 243). Evidence for organic grains is given by Wickramasinghe and Allen (1980, Nature, 287, 518). Hoyle and Wickramasinghe proposed organic polymers (1980, Astrophys. Space Sci., 72, 183, 247). Counter arguments appear in: Whittet et al. (1979, Nature, 281, 708), Whittet (1981, Q. Jl. R. Astron. Soc., 22, 3), Aitken and Roche (1981, MNRAS, 196, 39P).

Blanco and Bussoletti (1981, Astrophys. Space Sci., 78, 467) analyzed conditions for a consistent graphite fit. Harris et al. (1978, Ap.J., 226, 829) and McMillan (1978, Ap.J., 225, 417) examined the role of ice mantles in dense regions with anomalous extinction. The 45 μm water-ice band in Orion is reported by Erickson et al. (1981, Ap.J., 245, 148). A new form of solid carbon, carbyne, discovered by Whittaker (1978, Science, 200, 763) has been proposed as a component of grains by Webster (1980, MNRAS, 192, 7P).

Williams (1980, J. Phys. Colloq. 41, No.C-3, 225) reviewed the chemical role of grains. H_2 formation on graphite was rediscussed by Goodman (1978, Ap.J., 226, 87) and on metallic grains by Tabak (1978, Astrophys. Space Sci., 53, 279; 54, 211). Hunter and Watson (1978, Ap.J., 226, 477) calculated H_2 energies on grains. Molecular behaviour on surfaces was discussed by Aronowitz and Chang (1980, Ap.J., 242, 149). Bar-Nun et al (1980, A&A, 85, 197) considered formation of hydrocarbons on graphite. Various chemical effects of oxide grains are considered by Duley and Millar (1978, Ap.J., 220, 124; 1979, Ap.J.Lett., 233, L87) and Duley (1980, Ap.J., 240, 950). A possible origin of diffuse bands is proposed by Duley (1979, Ap.J., 227, 824). Consequences of trapped chemical energy is described by Clayton (1980, Ap.J.Lett., 239, L37). Bakulina et al (1980, Soviet Astron., 24, 203) investigated the formation of molecules on dust grains in the laboratory.

Charging of grains is considered by Gail and Sedlmayr (1980, A&A, 86, 380), Millet et al. (1980, A&A, 92, 6), Lafon et al. (1980, A&A, 95, 295) and Mukai (1981, A&A, 99, 1). Plasma effects on grain radio emission is discussed by Meyer-Vernet (1981, A&A, 97, 208). Coagulation of charged grains is examined by Simpson et al. (1979, Astrophys. Space Sci., 61, 65).

Grain dynamics in primordial nebulae is examined by Morfill et al (1978, Moon and Planets, 19, 211, 221), and Margolis (1979, Moon and Planets, 20, 49). Sedimentation is discussed by Flannery and Krook (1978, Ap.J., 223, 447) and Harrison (1978, Ap.J.Lett., 226, L95). Heydari-Malayeri and Testor (1981, A&A, 96, 219) studied a dusty H II region and Epstein (1980, MNRAS, 193, 723) very large acceleration by shocks. Kessel'man has studied coagulation and growth of dust grains in interstellar clouds (21.131.200; 26.131.013; 27.131.169; 1981, Astron. Zh., 58, 58). Bel'kovich and Vasil'ev (26.131.025) have considered dust motions in clouds. Dolginov et al. (1979, see books) have reviewed the theory of grain orientation by gas or photon flows in the magnetic field. Makalkin (27.081.080) considered the origin of dust in protoplanet clouds and segregation of different types of grains.

There are numerous infrared observations of circumstellar shells. Cohen (1980, MNRAS, 191, 499) observing young stars found the 10 μm feature may be present in absorption or in emission or not at all. This feature occurs in emission around RY Scuti (Grasdalen et al. 1979, Ap.J.Lett., 234, L129). Harvey et al. (1979, Ap.J., 231, 115) observed cool dust in the far IR from emission-line stars. IR measurements of carbon stars were reported by Gehrz et al. (1978, Ap.J.Lett., 221, L23), Goebel et al. (1980, Ap.J., 235, 104; 1981, Ap.J., 246, 455), Fazio et al. (1980, Ap.J.Lett., 237, L39), and Witteborn et al. (1980, Ap.J., 238, 577). The 10 μm silicate feature was observed in emission by Puetter et al. (1978, Ap.J. Lett., 223, L93) and Aitken et al. (1980, MNRAS, 193, 207). The latter propose that the shape of the band is an indicator of evolutionary stage. Forrest et al. (1979, Ap.J., 233, 611) studied the 10 and 18 μm emission in 10 stars. Far IR

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properties of dust in a reflection nebula were studied by Whitcomb et al. (1981, Ap.J., 246, 416). Observations of the planetary nebulae NGC 7027 are reported by McCarthy et al. (1978, Ap.J., 224, 109), Jones et al. (1980, Ap.J., 242, 141) and Melnick et al. (1981, Ap.J., 243, 170). Other planetaries including NGC 7027 were investigated by Willner et al. (1979, Ap.J., 234, 496). Jones et al. (op. cit) suggest that the 10 μm absorption may not always come from the same material. Mosely (1980, Ap.J., 238, 892) observed planetaries in the range (37-108 μm). Compact sources in H II regions were studied by Wynn-Williams et al. (1981, Ap.J., 246, 801) and Hefele and Holzle (1980, A&A, 88, 145). A number of emission features in W33 A was studied by Soifer et al. (1979, Ap.J.Lett., 232, L53). Organic material is proposed as the source of 6.0 and 6.8 μm absorptions. Dust distribution in the galactic center was described by Oda et al. (1979, A&A, 72, 309) and the 16-30 μm spectra discussed by McCarthy et al. (1980, Ap.J., 242, 965). Excitation mechanisms for IR emission features and a summary of observed features were given by Dwek et al. (1980, Ap.J., 238, 140). High resolution observations of the 3.28 μm feature by Tokunaga and Young (1980, Ap.J.Lett., 237, L93) show no structure. Its optical distribution in the Orion Nebula was reported by Sellgren (1981, Ap.J., 245, 138). Modelling of infrared radiation has been done by Dwek (1981, Ap.J., 246, 430; 247, 614) and Draine (1981, Ap.J., 245, 880) for regions of high excitation. Circumstellar shell models were investigated by Mitchell and Robinson (1980, MNRAS, 190, 669) and Yorke and Shustov (1981, A&A, 98, 125). Calculations for a cloud-star cluster association were performed by Rouan (1979, A&A, 79, 102). Cool dust shells around Wolf-Rayet stars were studied by Aitken et al. (1980, MNRAS, 192, 679).

Optical spectrum observations of dark nebulae Kh 179-185, 189, 194 have been made by Kurtanidze (1981, Astr. Circ., USSR, N 1158) and Kurtanidze and Nikolashvily (1981, ibid, N 1172). Esipov et al. (1980, Sov. Astron.Lett., 6, 231) and Melikian and Shevchenko (1980, Astrofiz., 16, 789) have studied optical radiation from IR nebulae.

Cometary nebulae were studied by Parsamyan and Petrosyan (22.134.046, 27.134.050), Glushkov (27.134.049) and Vandanyan (1980, Astrofiz., 16, 592). Discovery and detailed study of properties of high-latitude reflection nebulae have been carried out by Rozhkovskij et al. (22.134.041, 044), Rozhkovskij (1979, Trans. Alma-Ata Astr. Inst., 34, 3, 26; 1981, Astr. Circ., USSR, N 1149), Khristich (26.134.027) and Sabitov (1981, Astr.circ., USSR, N 1153). Voshchinnikov has calculated colors and polarization of reflection nebulae (21.134.021; 22.134.029; 1980, Astron. Zh., 57, 716) and has interpreted observations of some of them (1980, Astrofiz., 16 257; 1980, Vestnik Leningrad Univ. (LGU), N 19, 76). Pavlova (1979, Trans. Alma-Ata Astr. Inst., 34, 20) has considered connection of reflection nebulae with dark clouds and molecular emissions.

Sudden infrared brightening is generally accepted as an indicator of grain formation in circumstellar shells. For novae and supernovae, Bode and Evans (1979, A&A, 73, 113; 1980, A&A, 89, 158; 1980, MNRAS, 193, 21P) propose that the grains pre-exist the outburst and are heated by it. Sudden IR emission around a Wolf-Rayet star was observed by Williams et al. (1978, MNRAS, 185, 467) and Hackwell et al. (1979, Ap.J., 234, 133). The development and properties of dust shells around novae are described by Gehrz et al. (1980, Ap.J., 237, 855; 239, 570).

Mechanism of grain formation in nova envelopes and circumstellar shells has been further developed in several papers. Modifications of conventional nucleation were described by Lefevre (1979, A&A, 72, 61), Draine (1979, Astrophys. Space Sci., 65, 313) and Deguchi (1980, Ap.J., 236, 567). Lewis and Ney (1979, Ap.J., 234, 154) concluded from chemical kinetics that carbon formation is unlikely and iron grains may initiate the process, although iron kinetics was not analyzed. Vibrational disequilibrium in clouds and its significant consequences for condensation were treated by Nuth and Donn (1981, Ap.J., 247, 925). A kinetic theory of condensation using disequilibrium was outlined by Donn et al. (1981, Surface Sci., 106, 576). Iron condensation in planetary nebulae was discussed by Scalo and Shields (1979, Ap.J., 228, 521). Dwek and Scalo (1980, Ap.J., 239, 193) analyzed behaviour of grains in the solar neighbourhood. Coagulation was proposed by Jura (1980, Ap.J., 235, 63). Whittet and Blades (1980, MNRAS, 191, 309) suggest that mantle accretion causes growth but the mantle is not molecular ices. Formation of multi-core-mantle grains by coagulation was proposed by Simons et al (1981, Astrophys. Space Sci., 74, 31). A variety of grain destruction mechanisms were examined by Draine and Salpeter (1979, Ap.J., 231, 438). Sputtering of graphite in H II regions was calculated by Draine (1979, Ap.J., 230, 106). Disruption in cloud collisions was examined by Shull (1978, Ap.J., 226, 858) and in shocks by Cowie (1978, Ap.J., 225, 887), Raymond (1979, Ap.J.Suppl., 39, 1) and Havnes (1980, A&A, 90, 106). Solar wind destruction of particles was calculated by Mukai and Schwehm (1981, A&A, 95, 373). Supernova nucleosynthesis, grain formation and the solar system are reviewed by Clayton (1979, Space Sci. Rev. 24, 147); see also Fujimoto (1980, Publ. Astron. Soc. Japan, 32, 463). Possible connections between grains and depletion of elements in the interstellar gas have been discussed by de Boer (1979, Ap.J., 229, 132; 1981, 244, 848), Jenkins and Shaya (1979, Ap.J., 231, 55), Dwek and Scalo (1979, Ap.J.Lett., 233, L81), Snow et al. (1979, Ap.J., 234, 506), Snow and Jenkins (1980, Ap.J., 241, 161) and Duley (1980, Ap.J.Lett., 240, L47).

Reported correlations of diffuse band strengths with colour excess, (Schmidt, 1978, Ap.J., 223, 458; Sneden et al. 1978, Ap.J., 223, 168; Wu et al. 1981, A.J., 86, 755; Tug and Schmidt-Kaler, 1981, A&A, 94, 16) show significant scatter. Some bands correlate well. No fine structure is seen in the λ5780 band at high resolution (Snell and Vanden Bout, 1981, Ap.J., 244, 844).

Dust to gas ratios in M31 and M81 obtained from polarization and 21-cm appear to be similar to that in the Galaxy (Jura, 1979, Ap.J., 229, 485). Houck et al. (1980, Ap.J.Lett., 242, L65) interpret a 19 μm absorption as evidence for grains in M82. The 3.3 μm emission feature is seen in the Seyfert galaxy NGC 4151 (Cutri and Rudy, 1980, Ap.J.Lett., 241, L141) and the quasar 3C273 (Allen, 1980, Nature, 284, 323). Infrared emission in IC 342 is also interpreted as coming from heated grains (Becklin et al. 1980, Ap.J., 236, 441). Murawski (1979, Acta Astron. 29, 299) studied galaxy counts and obtained a much thinner obscuring dust cloud than Hoffmeister reported. Intergalactic dust and its effects on quasar distribution were discussed by Soltan (1979, Acta Astron. 29, 33). An examination of dust in quasars and in the intergalactic medium is presented by Davidson and Netzer (1979, Rev. Mod. Phys., 51, 715).

6. Star Formation

(B.G. Elmegreen)

Our understanding of the formation of the sun and stars has increased enormously in the last few years. This summary covers the following general topics: (1) Pre-main sequence stellar winds and high-pressure environments around young stars, (2) triggers for star formation, the origin of the initial mass function and the hydrodynamic collapse of protostars, (3) the average star formation rates and initial mass functions in galaxies, and (4) isotopic anomalies in meteorites and the origin of the solar system. Other important topics related to star formation in less direct ways include molecular cloud heating, formation or evolution, and newly discovered molecules or molecular transitions; these are covered in other sections. We emphasize only the observations and concepts that are most directly related to the formation and early evolution of present-day stars.

A. PRE-MAIN SEQUENCE (PMS) WINDS AND HIGH PRESSURE MOLECULAR ENVIRONMENTS AROUND YOUNG STARS

Circumstellar mass flows are thought to be responsible for several properties

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of T Tauri stars, for the origin of bipolar nebulae and expansional motions in dark clouds, and for the shock excitation of some emission-line sources, like Herbig-Haro (HH) objects and regions where vibrationally excited H_2 is found.

The envelopes of T Tauri stars have a complex structure, probably consisting of mass inflow and outflow, surface flares and circumstellar debris. Direct evidence for stellar winds with velocities up to 250 km s^{-1} is shown by blue-shifted absorption features in the spectra of several T Tauri stars (Schneeberger et al. 1979, Ap.J.Suppl., 41, 369). Such stars often show mass motions that can be attributed to both inflow and outflow, however, and the velocity structure of the emission lines can be variable (Ulrich and Knapp, 1979, Ap.J.Lett., 230, L99; Bastian and Mundt, 1979, A&A, 78, 181; Edwards, 1979, PASP, 91, 329; Appenzeller et al. 1980, A&A, 86, 113; Krautter and Bastian, 1980, A&A, 88, L6; Shanin, 1980, Astrometr. Astrofiz., 40, 28).

The mass flow around T Tauri stars may be related to extreme stellar surface activity, like flares (Worden et al. 1981, Ap.J., 244, 520) or magnetic phenomena (Norman and Silk, 1979, Ap.J., 228, 197; DeCampli, 1981, Ap.J., 244, 124). Gas with a temperature of 10^5 K is present near some T Tauri stars (Gahm et al. 1979, A&A, 73, L4; Cram et al. 1980, Ap.J., 238, 905; Appenzeller et al. 1980, A&A, 90, 184), and X-ray luminosities from these stars can be as high as 10^{31} erg s^{-1} (Gahm, 1980, Ap.J.Lett., 242, L163; Feigelson and DeCampli, 1981, Ap.J.Lett., 243, L89). The T Tauri stars with X-ray emission tend to be the most variable optically, as if the X-ray emission arises in flares (Gahm, op. cit.). Flares are indicated by UBV photometry as well (Zajtseva, 1978, Astrofiz., 14, 17; Worden et al. op. cit.). Mundt and Bastian (1980, A&A Suppl., 39, 245) attribute some of the variability of T Tauri stars to irregular infall of matter. The UV spectrum of RW Aur was found by Imhoff and Giampapa (1980, Ap.J.Lett., 239, L115) to be similar to that of the solar chromosphere, and by Shanin (1979, Soviet Astron., 23, 17) to be similar to that of a solar prominence. Chromospheric activity in T Tauri stars was also reported by Cohen and Kuhi (1979, Ap.J.Suppl., 41, 743), Heidmann and Thomas (1980, A&A, 87, 36), Ulrich and Wood (1981, Ap.J., 244, 147) and Gahm et al. (1981, MNRAS, 195, 59P). The proceedings of a symposium on "Flare Stars, Fuors and HH Objects" review these topics (Mirzoyan, 1980, Acad.Sci.Armenian SSR, Yerevan).

Additional material containing dust is found outside the region of high temperatures (Bastien and Landstreet, 1979, Ap.J.Lett., 229, L137; Walker, 1980, PASP, 92, 66; Rydgren, 1980, A.J., 85, 438; Hough et al. 1981, MNRAS, 195, 429). Yorke and Shustov (1981, A&A, 98, 125) and Shustov (1978, Nauchn. Inf., 42, 60) calculated the expected infrared and radio continuum radiation from dust cocoons around young stars.

Cohen and Kuhi (op.cit.) found that most T Tauri stars lie on convective tracks in the HR diagram; they derived stellar masses and ages for a large number of PMS stars, and studied various properties of the nearby regions of low mass star formation. Vogel and Kuhi (1981, Ap.J., 245, 960) found, in addition, that the rotational velocities of PMS stars on their radiative tracks fall into two groups according to the stellar masses; the low mass ($M<1.5M_\odot$) slow rotators must lose a significant amount of angular momentum before they show a photospheric spectrum.

Indirect evidence for strong winds from low mass PMS stars is found in the shock emission from HH objects near them, and from the appearance of outflow in the surrounding gas. The ionization resulting from a wind or from shocks around T Tauri was studied by Maran et al. (1979, A.J., 84, 1709). Some HH objects occur near OH or H_2O masers (Pashchenko et al. 1979, Pis'ma Astron.Zh., 5, 517; Rodriguez et al. 1980, Ap.J., 235, 845, 237, 26; Norris, 1980, MNRAS, 193, 39P), near regions of H_2CO emission (Loren et al. 1979, Ap.J., 234, 932) and near regions of vibrationally excited H_2 emission (Fischer et al. 1980, Ap.J. Lett., 238, L155; Elias, 1980, Ap.J., 241, 728). The spectrum of HH1 shows evidence for shock and H_2

excitation by a wind (Schwartz, 1981, Ap.J., 243, 197); Cohen and Schwartz (1979, Ap.J.Lett., 233, L77) derived a mass loss rate from the exciting star of 10^{-8} to 10^{-7} $M_{\odot}$ yr^{-1}. Similarly, the emission from HH24 shows shock excitation by a wind, but there is also some light reflected from the embedded star (Schmidt and Miller, 1979, Ap.J.Lett., 234, L191). An inverse correlation between the velocity of HH objects and the shock excitation was found by Schwartz and Dopita (1980, Ap.J., 236, 543); they suggested that the excitation was from shocked cloudlets immersed in a wind. Canto et al. (1980, A&A, 85, 128, 86, 327) made a model for HH objects that consisted of a stationary flow of stellar wind inside a cavity. UV observations of HH objects showed permitted line emission of unknown origin and rising continua at decreasing wavelengths (Ortolani and D'Odorico, 1980, A&A, 83, L8; Bohm et al. 1981, Ap.J.Lett., 245, L113; Brugel et al. 1981, Ap.J., 243, 874).

The recent discovery of bipolar molecular outflows in regions of star formation provides further evidence for large pressures from PMS stars. Bipolar flows have been studied in L1551 (Cudworth and Herbig, 1979, A.J., 84, 548; Snell et al. 1980, Ap.J.Lett., 239, L17; Fridlund et al. 1980, A&A, 91, L1; Beichman and Harris, 1981, Ap.J., 245, 589) and in Ceph A, S106, GL 490, NGC 2261 and Lk Hα 208 references to which are in Section 4. Models for bipolar outflow from young stars have been made by Elmegreen and Morris (1979, Ap.J., 229, 593) and Canto et al. (1981, Ap.J., 244, 102; 1981, Rev. Mex. Astron. Astrof., 5, 101).

Outflows from central energy sources are also shown by proper motions of H_2O masers in Orion (Downes et al. 1981, Ap.J., 244, 869) and in W51 (Genzel et al. 1981, Ap.J., 247, 1039). Models for the outflow in Orion were made by Downes et al. (op. cit.), Phillips and Beckman (1980, MNRAS, 193, 245), Chevalier (1980, Ap.Lett., 21, 57) and Solomon et al. (1981, Ap.J.Lett., 245, L19). This outflow appears to be associated with strong winds or radiation pressure from massive PMS stars; Downes et al. (op. cit) identify IRc2 as a primary energy source, and Bastien et al. (1981, A&A, 98, L4) attribute some of the energy to IRc4 as well. Aperture synthesis maps of several molecular transitions from this region were made by Welch et al. (1981, Ap.J.Lett., 245, L87). The visual extinction to the H_2 emitting region in Orion was determined to be 40 mag. by Simon et al. (1979, Ap.J. Lett., 230, L175), and the relative positions of the prominent IR sources in the KL nebula were discussed by Aitken et al. (1981, MNRAS, 195, 921); IRc4 appears to be embedded in more dust than either IRc2 or the BN object. Vibrationally excited H_2 emission from several other high-pressure regions of star formation were studied by Fischer et al. (op. cit., 1980, Ap.J.Lett., 240, L95).

Maser emission and compact continuum sources also show evidence for high densities and pressures in regions of star formation. Several studies of W3(OH) show a dense shell or ring around the newly formed massive star (Reid et al. 1980, Ap.J., 239, 89; Dreher and Welch, 1981, Ap.J., 245, 857; Scott, 1981, MNRAS, 194, 25P). VLA observations of compact continuum sources often show Trapezium-like clusters of massive stars (Beichman et al. 1979, Ap.J.Lett., 232, L47; Ho et al. 1981, Ap.J., 243, 526, 246, 761). Other observations of embedded young clusters have been made at infrared wavelengths for the W3 region (Zeilik, 1979, A.J., 84, 1566; Werner et al. 1980, Ap.J., 242, 601; Elmegreen, 1980, Ap.J., 240, 846), S140 (Dinerstein et al. 1979, Ap.J.Lett., 227, L39) and Mon R2 (Thronson et al. 1980, Ap.J., 237, 66). Extensive observations of Bγ emission from embedded stars have been made by Tokunaga and Thompson (1979, Ap.J., 229, 583, 231, 736, 233, 127), and of Bα emission by Simon et al. (1979, Ap.J., 230, 127, 232, 782). Various spatial correlations between sources of maser, infrared and radio emission were studied by Wright et al. (1981, Ap.J., 246, 426), Moorwood and Salinari (1981, A&A, 94, 299), Epchtein et al. (1981, A&A, 97, 1) and by other authors cited in Section 4.

Molecular observations of star-forming regions have revealed extremely high densities (>10^7 cm^{-3}) in Orion (Scoville et al. 1979, Ap.J.Lett., 232, L121; Smith et al. 1979, Ap.J., 233, 132; Morris et al. 1980, Ap.J., 237, 1) and W3(OH) (Pauls

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and Wilson, 1980, A&A, 91, L11), and densities of 10^6 cm^{-3} in Ophiuchus (Lada and Wilking, 1980, Ap.J., 238, 620; Loren et al. 1980, Ap.J.Lett., 240, L165). Some sources also appear to be clumpy, or to have several dense cores (Lang and Willson, 1979, Ap.J., 227, 163; Ho et al. 1979, Ap.J., 234, 912; 1980, Ap.J., 237, 38; 1981, Ap.J., 246, 761; Little et al. 1980, MNRAS, 193, 115). Models of self-absorbed emission line profiles were made for several clouds, giving evidence for infall or cloud contraction onto such cores (Loren et al. 1979, Ap.J., 227, 832; 1980, Ap.J., 242, 568; 1981, Ap.J., 245, 495; Myers, 1980, Ap.J., 242, 1013). These observations give a clear picture of star formation at various stages in dense cloud cores often showing intense interaction with the surrounding gas.

B. THEORIES OF STAR FORMATION

Theoretical studies have introduced several new processes that may be important during some phases of star formation. Kannari et al. (1979, Publ. Astron. Soc. Japan, 31, 395) and Yoshii and Sabano (1980, Publ. Astron. Soc. Japan, 32, 229) found that the fragmentation and collapse of a cloud can be induced or enhanced by thermal instabilities; they suggested that the abundance of heavy elements may be an important factor in determining the initial mass function (IMF). Norman and Silk (1980, Ap.J., 238, 158) proposed that low mass star formation inside dense clouds can be triggered and maintained by the continuous pressurization and coagulation of small clumps of gas that are swept up by the winds from other stars in the cloud. Regev and Shaviv (1980, A&A, 89, 61) considered gravitational instabilities in viscous, rotating clouds, showing that turbulent viscosity can lead to the unstable growth of perturbations that would otherwise be stabilized by rotation. In fact, Larson (1981, MNRAS, 194, 809) finding a Kolmogorov-type relationship between the linewidths and sizes of such clouds suggested that molecular clouds are highly turbulent.

Sequential star formation has been found in several more galactic sources: W4/W3 (Lada et al. 1978, Ap.J.Lett., 226, L39; Thronson et al. 1979, Ap.J.Lett., 229, L133), NGC 281 (Elmegreen and Moran, 1979, Ap.J.Lett., 227, L93), S252 (Lada and Wooden, 1979, Ap.J., 232, 158), ρ Oph (Falgarone, 1980, IAU Symp. 87, 183), S157, S158, and S159 (Israel, 1980, A.J., 85, 1612), Ceph OB4 (Grayzeck, 1980, A.J., 85, 1631), W58 (Israel, 1980, Ap.J., 236, 465; Read, 1981, MNRAS, 195, 371); this process has been discussed for young clusters in general by Krelowski and Strobel (1979, Acta Astron., 29, 211). The possibility that sequential star formation may occur on scales of several hundred parsecs has been raised by Efremov et al. (1979, Soviet Astron. Lett., 5, 12; Astrophys. Space Sci., 75, 407) in a study of star complexes. Other evidence that star formation can propagate over such scales is given by Meaburn (1980, MNRAS, 192, 365) for the LMC, and by Jensen et al.(1981, Ap.J., 243, 716) for M83. One implication of sequential star formation (Elmegreen and Lada, 1977, Ap.J., 214, 725), namely that massive stars tend to appear near the edges of cloud complexes, received some support when Gilmore (1980, A.J., 85, 894, 912) surveyed a large sample of dark cloud interiors without finding any significant evidence for embedded H II regions. More general properties of the large scale structure of star forming regions were studied by Shevchenko et al. (Soviet Astron., 1979, 23, 163; 1980, 24, No.6; 1981, 25, 25). Large scale propagating star formation also has implications for the structure of galaxies and for their average star formation rates (Seiden and Gerola, 1979, Ap.J., 233, 56; Gerola et al. 1980, Ap.J., 242, 517; Kaufman, 1979, Ap.J., 232, 707, 717; Comins, 1981, MNRAS, 194, 169), and for the formation and evolution of giant cloud complexes (Elmegreen et al. 1979, Ap.J., 231, 372; 1980, IAU Symp. 87, 191; Shevchenko, op. cit.). New theoretical work on sequential star formation in OB associations included the effects of cluster motion (Bedijn and Tenorio-Tagle, 1980, A&A, 88, 58). Giuliani (1980, Ap.J., 242, 219) discussed gravitational instabilities in the presence of ionization-driven instabilities at H II region-cloud interfaces, and Welter and Schmid-Burgk (1981, Ap.J., 245, 927) reconsidered criteria for the onset of star formation behind shock fronts. Sofue and Sabano (1980, Publ. Astron. Soc. Japan, 32, 623) proposed that star formation can occur sequentially at subsonic speeds as a result of chemical chain reactions in molecular clouds. The pressure-induced collapse of a spherical cloud was analyzed further by Hunter (1979, Ap.J., 233, 946), Izotov and Kolesnik (1980, Astrometr. Astrofiz., 40, 19) and Whitworth (1981, MNRAS, 195, 967).

A new compilation of the IMF for stars was made by Miller and Scalo (1979, Ap.J.Suppl., 41, 513). They found significant deviations from a Salpeter function at the high and low mass ends of the distribution, and they proposed that a log-normal function would best represent the data. Lucy and Ricco (1979, A.J., 84, 401) showed that the distribution of the mass ratio for binary stars was strongly concentrated around unity; van't Veer (1981, A&A, 98, 213) obtained a similar result for the initial masses of contact binaries. Claudius and Grosbøl (1980, A&A, 87, 339) investigated several nearby clusters and derived a power-law IMF with a slope of 1.9 for 2.2-10$M_{\odot}$ stars.

Silk and Takahashi (1979, Ap.J., 229, 242) sought to explain a power-law IMF for stars by considering the statistical properties of coagulation among dense clumps in a cloud. Bastien (1981, A&A, 93, 160) proposed that fragmentation influences the IMF for $M<M_{\odot}$ and fragment interactions give the IMF at higher mass. Bhattacharjee and Williams (1980, A&A, 91, 85) modelled the IMF by studying accretion onto pre-stellar nuclei.

Computer calculations of protostellar collapse have involved 3D fragmentation of rotating clouds without magnetic fields, and axisymmetric collapse of non-rotating magnetic clouds. Simulations of the collapse of rotating, non-magnetic clouds by Bodenheimer et al. (1980, Ap.J., 242, 209) show several important regimes for the parameter α(=thermal/gravitational energy): when α is small (<0.3), a cloud can fragment without first collapsing into a ring; when α is between 0.4 and 0.5, modest-amplitude, initial non-axisymmetric perturbations damp out, a ring appears, and the ring collapses before it fragments; when α is large, the initial perturbation still damps out and a ring forms, but the ring fragments before it collapses. Simplified analytical calculations show the same regimes for α (Boss, 1981, Ap.J., 244, 40). Such fragmentation leads to the transfer of angular momentum away from individual condensations and into orbital motions. Calculations of 3D collapse with rotation have been made by several groups. Fragmentation has been studied by Tohline (1980, Ap.J., 235, 866), Boss (1980, Ap.J., 237, 866), and Rozyczka et al. (1980, A&A, 83, 118). Sometimes a ring forms before fragmentation, and sometimes a bar forms (Wood, 1981, MNRAS, 194, 201). A nearby star may even induce fragmentation in a collapsing cloud (Boss, 1981, Ap.J., 246, 866). 2D collapse calculations produce rings (Tohline, 1980, Ap.J., 236, 160; Boss, 1980, Ap.J., 237, 563) or disks (Norman et al. 1980, Ap.J., 239, 968). In all cases, the initial conditions appear to be important in determining the final outcome of a collapsing cloud (Buff et al. 1979, Ap.J., 230, 839; McNally and Settle, 1980, MNRAS, 192, 917). Lucy (1981, IAU Symp. 93, 75) studied the fragmentation of rotationally supported spheroids into binary or multiple star systems. The influence of viscosity during collapse was considered by Rozyczka et al. (1980, A&A, 81, 347), Winkler and Newman (1980, Ap.J., 236, 201) and Regev and Shaviv (1981, Ap.J., 245, 934). A large amount of viscosity can change the collapse results significantly, possibly causing an accretion disk and single star to form instead of a ring and binary system.

Shustov et al. (1979, Nauchn.Inf., 46 63; 1981, Soviet Astron., 25, 61) *studied the formation and stability of cocoons around newly formed stars.* They investigated the dependence of the final stellar mass on initial conditions and traced the cloud-star evolution to compact H II region formation. The hydrodynamics of protostellar collapse was also calculated by Kolesnik (1980, Astrometr. Astrofiz., 40, 3, 41, 40). Stahler et al. (1980, Ap.J., 241, 637, 242, 226) derived a new method to treat such collapse utilizing different analytical approximations for different parts of the protostellar envelope; they followed the evolution of a

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solar mass protostar to the point when it reached the top of the Hayashi track.

2D collapse with frozen-in magnetic fields has been studied by Scott and Black (1980, Ap.J., 239, 166) for cloud masses exceeding the critically unstable mass. They found that the collapse leads to significant flattening along the field, and that the central field strength tends to increase as the square root of the central gas density. Nakano (1979, Publ. Astron. Soc. Japan, 31, 697) studied the contraction of a $50M_\odot$ protostar without flux freezing, and showed that only a $3M_\odot$ core can separate from the magnetically supported envelope and begin to collapse freely. Analytical calculations of magnetic configurations in collapsing clouds were made by Dudorov and Sazonov (1978, Nauch. Inf., 42, 110).

Analytical studies of magnetic rotational braking by Gillis et al. (1979, MNRAS, 187, 311) and by Mouschovias and Paleologou (1979, Ap.J., 228, 159, 230, 204; 1980, Moon and Planets, 22, 31; 1980, Ap.J., 237, 877) followed the time-dependent evolution of a rotating spheroidal or cylindrical cloud that is magnetically connected to a lower density medium. These authors show that the cloud may overshoot and then oscillate around its equilibrium position as it establishes corotation. Mestel and Paris (1979, MNRAS, 187, 337) showed that clouds more massive than the critical mass for a given magnetic flux can spin up during the collapse until they establish centrifugal-gravitational force equilibria; further contraction of the protostar proceeds only as angular momentum is lost through magnetic torques; lower mass clouds, on the other hand, can be supported by the field long enough to achieve corotation during contraction, unless the magnetic diffusion time is short, in which case they spin up like the higher mass clouds.

C. STAR FORMATION ON A GALACTIC SCALE

The average star formation rate (SFR) per unit mass was found to be slightly larger in galaxies with smaller ratios of gas mass to total mass (Lequeux et al. 1979, A&A, 71, 1; 1980, A&A, 90, 73). A SFR of $\lesssim 6M_\odot\ yr^{-1}$ was derived for our galaxy by Avedisova (1979, Soviet Astron., 23, 544), and the SFR per unit gas mass for massive stars in the nucleus of our galaxy was estimated to be 3 times higher than it is locally by Audouze et al. (1979, A&A, 80, 276). Our nucleus may have had a burst of star formation 10^7 years ago (Tutukov and Krugel, 1978, A&A, 67, 437; Rodriguez and Chaisson, 1979, Ap.J., 231, 697). The LMC has a normalized SFR similar to that in the solar neighbourhood (Dennefeld and Tammann, 1980, A&A, 83, 275). The recent history of star formation in LMC-type irregular galaxies NGC 6822 and IC 1613 was mapped by Hodge (1980, Ap.J., 241, 125); the sites of star formation in these galaxies move around in what appears to be a random fashion. Elmegreen and Elmegreen (1980, A.J., 85, 1325) showed that barred, LMC-type galaxies tend to have 30 Doradus-like giant H II regions at one of the ends of the bar, as if such star formation were preferentially triggered there by the compression of gas flowing around the bar. The possibility that star formation increases during galaxy-galaxy collisions was discussed for NGC 1512-1510 by Hawarden et al. (1979, A&A, 76, 230), NGC 6052 by Alloin and Duflot (1979, A&A, 78, L5) and for galaxy collisions in general by Smirnov and Komberg (1980, Astrofiz., 16, 431), and Madore (1980, A.J., 85, 507). Malin and Carter (1980, Nature, 285, 643) observed stars in extended regions outside of several elliptical galaxies and suggested that shock fronts driven by winds from the galactic nuclei triggered such star formation in the surrounding intergalactic medium.

There is some indication that the IMF varies from galaxy to galaxy, possibly being weighted toward intermediate-mass stars in M83 (Jensen et al. 1981, Ap.J., 243, 716) or toward more massive stars in late type galaxies in general (Zazov and Demin, 1979, Soviet Astron., 23, 531). Vangioni-Flam et al. (1980, A&A, 90, 73) suggested that the upper mass limit for stars is higher in galaxies with lower metallicities, and similarly, Puget et al. (1979, IAU Symp. 84, 105) suggested that the IMF for our galaxy is steeper inside than outside the solar circle.

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D. SOLAR SYSTEM FORMATION

Our concept of the formation of the solar system was revised dramatically several years ago when the high temperature inclusions in the Allende meteorite showed evidence for decay products of the short-lived radioisotope ^{26}Al (Wasserburg et al. 1976, Geophys. Res. Lett., 3, 109). Several new theories were then proposed concerning the role of supernovae during the sun's formation. Now the byproduct of another short-lived isotope, ^{107}Pd (with a half-life of 6.5x10^6 yrs) has been found in an iron meteorite (Kelly and Wasserburg, 1978, Geophys. Res. Lett., 5, 1079). Recent reviews of these and other isotopic anomalies in meteorites were compiled by Clayton (1978, Ann. Rev. Nuc. and Part. Sci., 28, 501) and Lee (1979, Rev. Geophys. Space Sci., 17, 1591). The possible origin in presolar grains of noble-gas anomalies was considered by Alaerts et al. (1980, Geochim. Cosmochim. Acta, 44, 189), and the origin of the FUN anomalies in giant gaseous protoplanets was considered by Consolmagno and Cameron (1980, Moon and Planets, 23, 3). Recent discussions about supernova pressures triggering the protosolar collapse, or about supernova ejecta contaminating the presolar material can be found in Clayton (1979, Space Sci. Rev., 24, 147), Reeves (1979, Ap.J., 231, 229) and Herbst and Rajan (1980, Icarus, 42, 35). An alternative model, where the ^{26}Al and other short-lived isotopes formed in the solar nebula during its exposure to intense solar flares, was reinvestigated by Worden et al. (1981, Ap.J., 244, 520). Meteoritic evidence for intense flare activity or T Tauri-like winds in the early sun was presented by Goswami and Lal (1978, Icarus, 40, 510).

7. H II Regions

(M. Peimbert)

A. INTRODUCTION

In the last three years the amount of work on galactic H II regions has been substantial, and that on extragalactic H II regions has increased considerably. Particular effort has been placed on molecular observations in the direction of H II regions to study the physical conditions of the star forming regions and of the interface between H II regions and dense molecular clouds, most of which work is reviewed in the preceding sections. The following discussion reviews representative papers on physical conditions, evolution, gradients, the nucleus of our Galaxy, and extragalactic H II regions.

B. PHYSICAL CONDITIONS

The presence of density variations in gaseous nebulae is well known but their origin is not well understood; these density variations produce temperature and ionization variations along the line of sight. Laques and Vidal (1979, A&A, 73, 97) have detected six condensations with $N_e \sim 10^6$ cm^{-3} in the central parts of the Orion nebula; they propose that these condensations are partially ionized globules with neutral cores. Van Gorkom et al. (1980, A&A, 89, 150) have detected compact components in W49A and W51A with $N_e > 10^5$ cm^{-3}. Nosov (1981, Astron. Zh., 58, 300) and Vidal (1979, A&A, 79, 93) have studied the effect of small-scale N_e and T_e fluctuations on the relative intensities of emission lines; Vidal finds that in the Gum nebula the densest regions are the hottest, in agreement with theory. Alternatively, Barker (1979, Ap.J., 227, 863) has derived T_e-values from forbidden lines and from continuum (bound-free) to line ratios of H in the optical region of several gaseous nebulae; within the accuracy of his measurements, he does not find evidence for temperature variations along the line of sight.

Shaver (1980, A&A, 91, 279; see also 1980, A&A, 90, 34; 1980, Symp. on Radio Recombination Lines, ed. Shaver, Reidel, hereafter RRL, p.63) has found that for a given H II region there is a unique frequency beyond which the non-LTE corrections to T_e are negligible, thus making it possible to derive highly reliable T_e values from radio recombination lines. Shaver et al. (1979, Nature, 280, 476) have found

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from radio recombination line observations several low-density nebulae with temperatures below 5000K; in two cases upper limits of 4700K are imposed by line widths alone. Based on new optical measurements of T_e, McCall (1979, Ap.J., 229, 962) does not find support for steep T_e or abundance gradients across the Orion nebula; a similar result is obtained by Kaler et al. (1979, Ap.J., 234, 909). Physical conditions, mainly EM and T_e values, have been derived from radio data by many authors: Silverglate and Terzian, 1979, Ap.J.Suppl., 39, 157; Wilson et al. 1979, A&A, 71, 205; Abraham et al. 1980, MNRAS, 193, 737; Matthews and Goss, 1980, A&A, 88, 267; Pedlar and Davies, 1980, RRL, 239; Felli and Harten, 1981, A&A, 100, 28.

Several sets of ionization structure models have been computed emphasizing different aspects: the effects of stellar temperature and gas density, with a homogeneous distribution, and including C, N, O, Ne, S, Mg, Al, Si, Cℓ, Ar and Fe (Koppen, 1979, A&A Suppl., 35, 111; 1980, ibid, 39, 77); the influence of abundances and different density distributions (Stasinska, 1980, A&A, 84, 320); and the presence of small scale, optically thin density enhancements (Koppen, 1979, A&A, 80, 42). Pankonin et al. (1980, A&A, 89, 173) from radio observations obtain a helium ionized volume smaller than the hydrogen one in the Orion nebula in agreement with optical observations. A review on recombination lines (mainly C^+) from the partially ionized medium adjacent to H II regions has been presented by Pankonin (1980, RRL, p.111).

Several reviews and new determinations of abundances in H II regions derived from optical methods are present in the literature (1979, Liege XXII^e, 451, 465, 477, 489; 1979, Mem. Soc. Astron. Italiana, 79; 1981, Ap.J., 245, 560; 1981, Ap.J., 246, 434). The reliability of chemical abundance determinations in H II regions has been studied by several authors (1980, A&A, 84, 320; 1981, A&A, 93, 362; 1981, Ap.J., 244, 493). There have been three determinations of abundances in the Orion nebula based on IUE data (Perinotto and Patriarchi, 1980, Ap.J.Lett., 235, L13; Torres-Peimbert et al. 1980, Ap.J., 238, 133; Bohlin et al. 1980, Ap.J., 239, 137); these three groups find a C/O ratio similar to the solar one implying that the amount of carbon locked up in grains inside the Orion nebula is not substantial. The observations of fine-structure transitions in the far infra-red (e.g. O I, O III, Ne II, S II, S III, S IV, N II, Ar III) have increased at an accelerated pace. (1978, MNRAS, 185, 179; 1979, Ap.J.Lett., 227, L29; 1979, ibid, 227, L35; 1979, Ap.J., 229, 981; 1979, Ap.J., 231, 711; 1979, Ap.J., 232, 139; 1979, A&A, 74, 302; 1980, A&A, 86, 231; 1980, A&A, 90, 304; 1980, Ap.J., 238, 565; 1980, Ap.J.Lett., 240, L99; 1981, Ap.J., 244, 66). From these lines it has been possible to derive abundances that are almost independent of temperature and reddening; the derived abundances in the H II regions of the solar neighbourhood are similar to the solar values.

The study of the radial velocity fields of H II regions allows more precise modelling taking into account expansion, rotation, turbulence, one or more shells in a given direction, relative position of the H I - H II interfaces, possible relationships between H II regions and molecular clouds and energy sources needed to maintain the observed velocity field. There are observations of the Orion nebula and NGC 7538 consistent with the idea that ionized material is flowing from the face of the neutral cloud in the direction of the observer (Pankonin et al. 1979, A&A, 75, 34; Balick et al. 1980, PASP, 92, 22; Deharveng et al. 1979, A&A, 71, 151). The presence of stellar winds has been proposed to explain large scale splitting of the [N II] lines in IC 1318 and [N II] filamentary structures in the Orion nebula (Canto et al. 1979, MNRAS, 187, 673; Taylor and Axon, 1979, MNRAS, 188, 687). Other papers on velocity fields include: 1979, Rev. Mexicana Astron. Astrof., 4, 271, 331, 337; 1980, ibid, 5, 39, 79; 1979, A&A, 75, 365; 1979, A&A, 86, 248; 1981, Ap.J., 240, 834; 1979, A.J., 84, 77; 1980, MNRAS, 190, 111; 1980, Astrophys. Space Sci., 73, 411; 1980, Ap.J., 242, 584.

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Heiles and Chu (1980, Ap.J.Lett., 235, L105) have determined a line of sight component of the magnetic field strength of ∿ 10 microgauss for S232 from Faraday rotation.

Review papers related to dust grains in H II regions are those by Panagia (1978, Infrared Astronomy, Reidel, 115) and by Savage and Mathis (1979, Annu. Rev. Astron. Astrophys., 17, 73). Tielens and de Jong (1979, A&A, 75, 326) have computed the IR emission from dust in compact H II regions. From UV data it has been found that most of the continuum observed in the Orion nebula is due to dust-scattered light from the ionizing O and B stars; also from these data the dust-scattering efficiency and albedo as a function of wavelength have been estimated (1980, Ap.J., 238, 614; 1980, Ap.J., 239, 137; 1981, Ap.J., 249, 99; 1981, Ap.Lett., 22, 135). Far IR emission detected by several groups seems to be due to thermal radiation by dust grains at the H I - H II interface or in the dense molecular cloud behind the H II region (1979, A&A, 74, 133; 1979, A&A, 76, 60, 86; 1979, Ap.J., 227, 114; 1979, Ap.J., 228, 118; 1979, Ap.J., 230, 133 and 233, 575; 1979, A.J., 84, 1328).

C. EVOLUTION

Dynamical evolution models have been studied by several authors (1979, A&A, 77, 165; 1980, Ap.J., 240, 514). Models based on the assumption that the ionizing star is born within a cold molecular cloud, under a variety of different initial conditions, have been carried out by Tenorio-Tagle and coworkers (1979, A&A, 71, 59; 1979, ibid., 80, 110; 1979, Ap.J., 233, 85); in these models the ionizing star is able to disrupt the molecular cloud and the ionized cloud material expands into the intercloud medium with velocities larger than 30 km s^{-1} (champagne flow model); observations of S115 and S252 apparently agree with this model (1980, A&A, 89, 140, 363). Israel (1980, A.J., 85, 1612) has found that more evolved H II regions tend to be associated with smaller CO cloud masses, in agreement with the suggestion by Mazurek (1980, A&A, 90, 65). It has been suggested that the observed velocity field in a large number of H II regions is due to stellar winds, and observations supporting this idea and ages based on it are given in: 1979, Ap.J., 234, 162; 1980, Ap.J., 239, 65; 1979, A&A, 73, 132; 1980, MNRAS, 190, 403. Observations of the Rosette nebula and possible explanations for the presence of the central cavity have been discussed (1979, A.J., 84, 1335; 1979, Ap.J., 229, 971; 1980, Astron. Zh., 57, 348; 1980, A&A Suppl., 40, 33). The study of the velocity field and chemical abundances of ring nebulae around WR stars has continued; the overabundances of N and He are well established as well as the presence of substantial mass loss from the central stars (1980, Pis'ma Astron. Zh., 6, 350; 1980, A&A, 88, 117; 1981, Ap.J., 243, 184; 1981, Ap.J., 245, 154; 1981, Ap.J., 249, 195).

D. GALACTIC GRADIENTS

The determination of galactic gradients is very important for models of galactic chemical evolution and to compare our galaxy with other galaxies. From radio recombination lines originating in the 4-14 kpc interval of galactocentric distance, a gradient in T_e has been found by several authors ($\Delta T_e/\Delta R \sim 300$-400K kpc^{-1}), and this is presumed to be mainly due to an abundance gradient (1979, A&A, 77, L3 and 80, L3; 1979, Ap.J., 229, 524; 1980, RRL, 225; 1980, MNRAS, 192, 179; 1981, MNRAS, 196, 889). The He ionization gradient derived from radio observations has been interpreted as reflecting a general decrease of the He abundance with galactic radius (1980, RRL, p.99; 1980, A&A, 87, 269; 1981, Vistas in Astronomy, 24, 355); other authors do not find a clear-cut correlation between helium ionization and galactocentric distance (1979, Ap.J., 229, 524; 1980, MNRAS, 192, 179). Talent and Dufour (1979, Ap.J., 233, 888) have estimated the O and N abundance gradients from optical observations of four H II regions in the Perseus arm.

E. GALACTIC CENTER

A review on recombination line surveys has been presented by Pauls (1980, RRL, p.159); Downes et al. (1979, A&A Suppl., 35, 1) present data on 74 continuum radio sources and information on the associated extended components. Pitault and Cesarsky (1980, A&A, 82, 203) have been able to interpret the recombination line observations of Sgr B2 in the framework of normal He abundance and the influence of collisional broadening. Radio and IR observations of compact clouds of ionized gas within Sgr A West by Rodriguez and Chaisson (1979, Ap.J., 228, 734) and Lacy et al. (1980, Ap.J., 241, 132) combined with the assumption of Keplerian motions indicate a central pointlike mass of several $10^6 M_\odot$. From fine-structure transitions it has been found that the ionization of Sgr A West is similar to that produced by stars with a T_{eff} of 32000 to 40000K (1980, Ap.J., 241, 132; 1980, Ap.J.Lett., 241, L43). From these and other similar observations it has been suggested that Ne and Ar abundances are higher than solar by factors of 4 and 2 respectively while S is at most overabundant by a factor of 2 (1979, Ap.J., 228, 734; 1981, Ap.J., 248, 524; 1980, Ap.J., 242, 965).

F. EXTRAGALACTIC H II REGIONS

Catalogues of H II regions in other galaxies have been presented by several authors (1979, PASP, 91, 280; 1980, A&A Suppl., 39, 97; 1980, Ap.J., 238, 17). Typical papers on the physical conditions in extragalactic H II regions based on UV, optical and radio observations are: 1980, A&A, 84, 167; 1980, A&A, 85, L21; 1980, A&A, 86, 304; 1980, A&A, 90, 246; 1980, Ap. Lett., 21, 1; 1981, Proc. Natl. Acad. Sci. USA, 78, 1994; 1981, PASP, 93, 422. Most of the emphasis in the study of extragalactic H II regions has been on abundances and chemical evolution of galaxies, two excellent reviews on these topics being those by Searle (1979, Liege XXII^e, 437) and by Pagel and Edmunds (1981, Annu. Rev. Astron. Astrophys., 19, 77). Illustrative papers on chemical abundances are: 1979, Publ. Astron. Soc. Japan, 31, 635; 1979, Proc. Natl. Acad. Sci. USA, 76, 1525; 1980, Astrophys. Space Sci., 68, 335; 1980, PASP, 92, 134; 1981, A&A, 99, 341; 1981, MNRAS, 195, 839. Papers on abundance gradients across the disks of spiral galaxies are: 1979, A&A, 78, 200; 1980, A&A, 83, 100; 1981, A&A, 101, 377; 1980, Ap.J., 235, 783; 1980, Ap.J., 236, 119; 1979, MNRAS, 189, 95; 1980, MNRAS, 193, 219; 1981, MNRAS, 195, 939. There have been several studies of H II regions in dwarf irregulars and blue compact galaxies (1979, A&A, 80, 110; 1980, Ap.J., 240, 41; 1981, Ap.J., 243, 127; 1981, Ap.J., 246, 38; 1981, Ap.J., 248, 468); two of the main results are that $\Delta Y/\Delta Z \sim 2$-3 and that the pregalactic helium abundance by mass, Y_p, lies between 0.22 and 0.23.

8. Planetary Nebulae

(Y. Terzian)

A. GENERAL PROPERTIES AND STATISTICS

The last comprehensive volume on planetary nebulae was published in 1978 (IAU Symposium 76, D. Reidel Publ. Co., ed. Terzian). A general review of planetary nebulae was presented by Terzian (1980, Q. Jl.R. Astr. Soc. 21, 82). Acker et al. (1981, A&A Suppl., 43, 265) have updated the Strasbourg catalogue and bibliographical index of planetary nebulae to include the period from 1965-1979.

The distances to planetary nebulae remain a topic of great debate. Maciel and Pottasch (1980, A&A, 88, 1) derived a new distance scale by using an empirical relation between mass and radius of planetary nebulae, and on the basis of these results Maciel (1981, A&A, 98, 406) calculated various statistics for planetary nebulae. Pottasch (1980, A&A, 89, 336) gave a new determination of planetary nebula masses. Milne (1981, preprint) has suggested a new distance scale based on the radio emission from planetary nebulae. Pottasch et al. (1981, preprint) gave several distance estimates for NGC 7027 based on different methods, and Jacoby and Lesser (1981, A.J., 86, 185) estimated upper limits to the distances of several nearby galaxies using planetary nebulae.

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Radio recombination line observations of planetary nebulae have been reviewed by Terzian (1980, Radio Recombination Lines, ed. Shaver, hereafter RRL, p.75). Radio fluxes and extinctions were determined for 167 planetary nebulae by Milne (1979, A&A Suppl., 36, 227). Milne and Aller (1980, A.J., 85, 17) advanced a model for the mean galactic absorption, and Lerche and Milne (1980, A.J., 85, 13) discussed the implications of fluctuations in the extinction to planetary nebulae in relation to the turbulent structure of the galaxy. The extinction to NGC 7027 was discussed in detail by Seaton (1979, MNRAS, 187, 785). Luminosity distributions of the planetary nebulae in the SMC and LMC were determined by Jacoby (1980, Ap.J. Suppl., 42, 1).

The kinematics of planetary nebulae observed toward the galactic anticenter were discussed by Purgathofer and Perinotto (1980, A&A, 81, 215). Isaacman (1980, A&A, 81, 359) made a radio search for planetary nebulae in the galactic center, and VLA studies by Isaacman et al. (1980, A&A, 86, 254) confirmed one source to be a planetary nebula. Mass models for the galactic bulge were estimated on the basis of planetary nebulae toward the galactic center by Isaacman (1981, A&A, 95, 46). Acker (1980, A&A, 89, 33) discussed the connection between kinematics and chemical class of planetary nebulae.

Adams et al. (1980, The Obs. 100, 209) measured accurate coordinates for the planetary nebula in M15. Wehmeyer and Kohoutek (1979, A&A, 78, 39) found no evidence of variation in the radial velocity of the central star of NGC 1360. Kohoutek (1979, IBVS, 1672) discovered that the central star of Sh 2-71 is variable. Purgathofer and Weinberger (1980, A&A, 87, L5) reported on a very large low surface brightness planetary nebula.

B. YOUNG PLANETARY NEBULAE

Several large scale studies of "stellar" and compact planetary nebulae were undertaken. Johnson et al. (1979, Ap.J., 223, 919) measured radio flux densities, brightness temperatures and dimensions for eight stellar planetary nebulae using the VLA radio telescope. Kwok et al (1981, Ap.J., in press) studied about 40 compact nebulae and suggested at least two new young objects on the basis of high emission measure and optical thickness. Kohoutek and Martin (1981, A&A Suppl., 44, 325) measured line and continuum fluxes for 30 compact planetary nebulae and Martin (1981, A&A, 98, 328) derived interstellar reddening, electron temperatures, and He abundances.

A number of suspected young planetary nebulae received further study. M 2-9 was observed in the near infrared by Swings and Andrillat (1979, A&A, 74, 85) and in the visible by Schmidt and Cohen (1981, Ap.J., 246, 444). Kohoutek and Surdej (1980, A&A, 85, 161) also investigated M 2-9 and found evidence of rotation and complex structure. Schmidt and Cohen studied CRL 618 as well as M 2-9 finding evidence in both of central high-density regions and condensations in the lobes. Kwok and Feldman (1981, Ap.J., in press) found that CRL 618 is undergoing a secular increase in its radio flux and interpreted this as an expanding H II region. Andrillat and Swings (1980, 5th European Reg. Meeting, Liege) found evidence of spectral variations in V 1016 Cyg and HM Sge in the near infrared. Mayor and Acker (1980, A&A, 92, 1) have reported in detail on the radial velocity changes of FG Sge. Kwok(1981, Effects of Mass Loss on Stellar Evolution, in press) proposed that HM Sge is an interesting binary system. Purgathofer and Stoll (1981, A&A, 99, 218) found variations in the optical spectrum of IC 4997.

C. MASS LOSS

Reviews of mass loss mechanisms by Zuckerman and Kwok are in the literature listed in the Introduction and in (1980, J. Roy. Astron. Soc. Can., 74, 216); Kwok argued that the radiation pressure on grains expands the red giant envelope, eventually exposing the hot core of the star, which drives a high velocity wind into the envelope. Zuckerman on the other hand suggests that some instability

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drives the initial mass loss followed by grain acceleration.

Giuliani (1981, Ap.J., 245, 903) presented a detailed model of a planetary nebula driven by a fast stellar wind. P Cygni type lines were observed in two planetary nebulae. Castor et al. (1981, MNRAS, 194, 547) obtained IUE data for NGC 6543 pointing to a terminal velocity of about 2150 km/s. Greenstein (1981, Ap.J., 245, 124) noted P Cygni profiles in Abell 30 as well as anomalous internal absorption. Livio et al. (1979, MNRAS, 188, 1) presented a model of mass loss through a Lagrange point of a binary nucleus.

D. CENTRAL STARS

A number of authors investigated the temperatures of central stars in detail. Kohoutek and Martin (1981, A&A, 94, 365) made a careful study of 11 stellar planetary nebulae and derived standard Zanstra temperatures which are in rough agreement with the Harman-Seaton sequence. Pottasch (1981, Physical Processes in Red Giants, 447) reviewed various temperature determination methods and found considerable disagreement with the Harman-Seaton sequence. Helfer et al. (1981, A&A, 94, 109) pointed out that dust in planetary nebulae can cause the usual Hβ Zanstra temperature estimates to be too low. Pottasch (1981, A&A, 94, L13) noted that there is also a bias against observing higher temperature central stars. Pilyugin and Khromov (1979, Astron. Zh., 56, 759) have also derived Zanstra temperatures for the central stars of planetary nebulae.

Natta et al. (1980, A&A, 84, 284) discussed a method for determining the far UV flux of the stars from the ionization state of the planetary nebulae. Bohlin et al. (1981, Ap.J., in press) obtained IUE spectra for the central stars of NGC 6853 and NGC 7293, and determined several stellar parameters for each.

Schonberner (1981, A&A, in press) developed an extensive evolutionary model of central stars finding a sharply peaked mass distribution at 0.6 solar masses. Acker (1981, Comptes Rendus Sur Les Journees de Strasbourg, 42) has presented a short review on the central stars of planetary nebulae, where she also lists the known objects in binary stellar systems.

E. DUST

Aitken et al. (1979, Ap.J., 233, 925) and Aitken and Roche (1981, preprint) completed 8-13 μm studies for about two dozen planetary nebulae. They distinguished primarily two classes of dusty nebulae: oxygen rich (silicate), including mainly very low excitation objects as well as compact planetary nebulae; the other category is carbon rich (silicon carbide). Cohen and Barlow (1980, Ap.J., 238, 585) presented 10 μm photometry for 23 nebulae, deducing grain heating mechanisms. A new emission feature at 24 μm, also associated with carbon stars, was identified by Forrest et al. (1981, Ap.J., 248, 195).

Harrington and Marionni (1981, NASA-CP, 2171, 623) modelled several planetary nebulae with IUE data and found substantial Si depletion and variable Mg depletions, probably reflecting differing degrees of grain formation.

NGC 7027 was singled out in several studies. Pequignot and Stasinska (1980, A&A, 81, 121) found an abundance gradient of gaseous Mg and attributed it to incorporation in grains at larger radii. Kwok (1980, Ap.J., 236, 592) modelled IR observations of this nebula with a 'warm-dust' central component surrounded by a 'cold-dust' envelope. However, Gatley (1981, preprint) found that 12.5 and 34 μm profiles are similar to Bγ emission, suggesting that the far infrared radiation does not come from a neutral envelope. Isaacman (1981, preprint) mapped the central region of NGC 7027 at 3.28 μm and argued that small hot grains are well mixed with the gas and then heated by Lyα photons. Natta and Panagia (1981, Ap.J., 248, 189) also present evidence for the dust grains being mixed with the ionized gas.

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Jacoby (1979, PASP, 91, 754) found photographic evidence of bright central nebulosities in Abell 30 and Abell 78 which may explain the high dust temperatures *suggested by infrared colours, in addition to the cool component.*

F. COMPOSITION

A wealth of new International Ultraviolet Explorer (IUE) data became available. Seaton (1980, Highlights of Astron., 5, 247) and Peimbert (1981, NASA-CP, 2171, 557) reviewed some of the ultraviolet spectra and abundances for planetary nebulae. A number of surveys of planetary nebulae were conducted to determine elemental abundances. Silverglate et al. (1979, A.J., 84, 345) detected no OH emission from planetary nebulae. Walmsley et al (1981, A&A, 96, 278) observed high order transitions in H and He. Feibelman et al. (1981, A&A, 86, 881) and Heap and Stecher (1981, NASA-CP, 2171, 657) attributed a UV absorption feature to H_2^+. Feibelman (1981, NASA-CP, 2171, 613) found electron densities from C III] transitions. Boggess et al. (1981, NASA-CP, 2171, 663) presented UV emission-line fluxes for 28 planetary nebulae. Barker (1980, Ap.J., 237, 482) found low Ar abundances for three halo nebulae in the optical. The ionization structure and Ar abundances of eleven nebulae were discussed by French (1981, Ap.J., 246, 434) and Beck et al. (1981, preprint) combined infrared with optical observations to find Ne, S, and Ar abundances for 18 nebulae.

Many individual planetary nebula spectra were studied, particularly by IUE. The carbon abundance in IC 418: Harrington et al. (1980, MNRAS, 191, 13) and Clavel et al. (1981, MNRAS, in press). IC 4997: Flower (1980, MNRAS, 193, 511). NGC 2371 and its central star: Pottasch et al. (1980, Proc. 2nd European IUE Conf., 185; and 1981, A&A, in press). NGC 5189 and NGC 6905: Johnson (1981, Ap.J., in press). NGC 6572: Flower and Penn (1981, MNRAS, 194, 13P). NGC 6720 and its ionization structure in the visible and UV: Barker (1980, Ap.J., 240, 99; and 1981, preprint). NGC 6853 in the visible: Hua and Louise (1981, A&A, 98, 397). NGC 7027 in infrared: Forrest et al. (1980, Ap.J.Lett., 240, L37). NGC 7662 in UV: Harrington et al. (1981, MNRAS, in press).

IUE data and abundance models for 7 high excitation nebulae were presented by Marionni and Harrington (1981, NASA-CP 2171, 633). Models of high excitation nebulae based on optical and IUE data were discussed by Aller and Keyes (1981, NASA-CP, 2171, 649) and by Aller and Czyzak (1981, preprint), and moderate to high excitation nebulae were considered by Aller (1981, preprint). IUE observations of NGC 3918 and IC 2448 were presented by Torres-Peimbert et al. (1981, NASA-CP, 2171, 641). Optical studies of Abell 30 and Abell 78 were made by Kaler (1981, preprint).

Several detailed studies of the chemistry of planetary nebulae were also completed. The theory of radio recombination lines was reviewed by Seaton (1980, RRL, p.3). Harrington et al. (1981, MNRAS, 195, 21) discussed the C III λ2297 dielectronic recombination line. Better parameters for the [Ne IV] $^2D \rightarrow ^4S$ lines were obtained by Lutz and Seaton (1979, MNRAS, 187, 1P) from studies of NGC 7662. Flower and Perinotto (1980, MNRAS, 191, 301) studied the importance of He II Lyα photons on other line intensities. Saraph and Seaton (1980, MNRAS, 193, 617) calculated oscillator strengths for O III. Charge transfer reaction rates were studied empirically with the use of models by Pequignot (1979, A&A, 78, 29; 1980, A&A, 83, 52, 81, 356) who occasionally found disagreement with the theoretical rates. Butler, Dalgarno and Heil collaborated on a number of papers dealing with calculated charge transfer rates between a variety of heavy ions and H or He (1979, Ap.J., 234, 765; 1980, Ap.J., 241, 442 and 838; 1980, A&A, 89, 379; 1981, Phys. Rev. 'A', 23, 1100; and 1981, Ap.J., 245, 793).

G. INTERACTIONS WITH THE INTERSTELLAR MEDIUM

The "snowplough" effect of a planetary nebula moving through the interstellar medium was investigated by Isaacman (1979, A&A, 77, 327). Jacoby (1981, Ap.J., 244, 903) found that Abell 35 is probably an example of such an interaction.

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Peimbert and Serrano (1980, Rev. Mexicana Astron. Astrof., 5, 9) studied the effect of interstellar medium enrichment of helium and nitrogen by different classes of planetary nebulae.

9. Supernova Remnants

(L. A. Higgs)

The state of supernova-remnant (SNR) research at the beginning of the period covered by this review is summarized by papers presented at the workshop on Supernovae and Supernova Remnants held at Erice, Italy (1978, Mem. Soc. Astron. Italiana, 49, 299) and at the Joint Australia-USSR-USA Symposium on Pulsars and Supernova Remnants (1979, Aust. J. Phys., 32, 1).

A number of theoretical papers have dealt with the stability of Sedov-blast models (Cheng, 1979, Ap.J., 227, 955; Newman, 1980, Ap.J., 236, 880; Bernstein and Book, 1980, Ap.J., 240, 223). The effects of decreasing density ahead of the expanding remnant have been studied by Shapiro (1980, Ap.J., 236, 958) while Chieze and Lazareff (1981, A&A, 95, 194) and Cowie et al. (1981, Ap.J., 247, 908) have studied the expansion of a remnant into an inhomogeneous medium. Tsunemi and Inoue (1980, Publ. Astron. Soc. Japan, 32, 247) treat the subsequent evaporation of engulfed H I clouds. Jones et al. (1980, Space Sci. Rev., 27, 579) have investigated the role of Rayleigh-Taylor instabilities in the very early stages of remnant evolution, with regard to the formation of high-velocity "knots", and Cui (1980, Acta Astron. Sinica, 21, 184) has re-evaluated the part reverse shocks play in the early evolution.

Caswell and Lerche (1979, Proc. Astron. Soc. Aust., 3, 343) have presented a generalized approach to the radio evolution of remnants, while Reynolds and Chevalier (1981, Ap.J., 245, 912) give a detailed model of the radio evolution of SNRs with particular application to Tycho's remnant. The later stages of SNR evolution have been modelled by Preite-Martinez (1981, A&A, 96, 283) and by Falle (1981, MNRAS, 195, 1011). Abundance effects (related to cooling efficiency) on SNR evolution are discussed by Fukunaga and Sabano (1980, Sci. Rep. Tohoku Univ., 1, 30). The possible role of pre-supernova stellar winds in the production of filamentary structure is discussed by Bychkov (1979, Astron.Zh., 56, 781). The evolution of SNRs embedded in dense molecular clouds has been discussed in Section 2, as also the interaction of SNRs with the ISM. If hot tenuous gas fills most of interstellar space, Higdon and Lingenfelter (1980, Ap.J., 239, 867) derive a galactic supernova rate of one per 30 years.

Physical conditions in SNR shocks are the subjects of several papers. Raymond (1979, Ap.J.Suppl., 39, 1) and Shull and McKee (1979, Ap.J., 227, 131) have constructed shock models, the latter considering the pre-shock ionization in a self-consistent manner. Ohtani (1980, Publ. Astron. Soc. Japan, 32, 11) considers radiative cooling in the post-shock gas, while Dopita (1978, Proc. Astron. Soc. Aust., 3, 208) outlines the problems in interpreting shock-excited spectra. Chevalier et al. (1980, Ap.J., 235, 186) apply these concepts to the optical spectrum of Tycho's SNR. Itoh (1979, Publ.Astron. Soc. Japan., 31, 541) shows that the X-ray spectrum of a shock-heated plasma should appear to arise from two thermal components; he has also calculated (1981, Publ. Astron. Soc. Japan, 33, 1) the optical spectrum of shock-excited oxygen gas with a view to interpreting the pure oxygen-line spectra of some filaments.

The creation of cosmic-ray particles in SNRs and the problem of their subsequent escape have been the subjects of many studies: acceleration in shocks (Eichler, 1979, Ap.J., 229, 419; Shapiro, 1979, AIP Conf. Proc. No. 56, 295; Pesses, 1979, AIP Conf. Proc. No. 56, 107; Ostriker, 1979, AIP Conf. Proc. No. 56, 357; Blandford and Ostriker, 1980, Ap.J., 237, 793; Toptyghin, 1980, Space Sci. Rev., 26, 157; Gurevich and Rumyantsev, 1980, Astrophys. Space Sci., 72, 261), energy losses (Bulanov and Dogel', 1979, Pis'ma Astron. Zh., 5, 521), and wave/particle interactions within the remnant and the question of the importance of scattering and subsequent adiabatic energy loss (Holman et al. 1979, Ap.J., 228, 576; Morfill and Scholer, 1979, Ap.J., 232, 473; Foote and Kulsrud, 1979, Ap.J., 233, 302; and Zweibel, 1979, AIP Conf. Proc. No. 56, 319).

The nature of the filled-centre SNRs (plerions) is still a matter of great interest. Shklovsky (1980, PASP, 92, 125) proposes that these are short-lived remnants of Type II supernovae. On the other hand, Kochhar (1981, JAA, 2, 87) argues that they arise from a second supernova event in a close binary. Radhakrishnan and Srinivasan (1980, JAA, 1, 25) suggest that the SNR morphology depends on whether the remnant contains an active pulsar, which ultimately depends on the magnetic-field strength of the central neutron star. Caswell (1979, MNRAS, 187, 431) and Weiler and Panagia (1980, A&A, 90, 269) discuss the evolution of plerions, of which about a dozen are now known. From the kinematics of old SNRs, Lozinskaya (1980, Astron. Zh., 57, 707) has determined the probable types of the parent supernovae.

The prototype plerion, the Crab Nebula, has been the topic of several theoretical studies. Salvati (1979, A&A, 72, 261) has shown that a previously proposed model for coherent optical emission from the Crab wisps, is inoperative. Machabeli and Usov (1979, J.Phys.Colloq. 40, No. C7), Kundt and Krotscheck (1980, A&A, 83, 1), Weinberg (1980, Ap.J., 235, 1078) and Stepanyan (1980, Izv. Krim. Ast. Obs., 62, 79) have all modelled the nebula and its central pulsar. Luheshi and Stewart (1979, A&A, 75, 185; 1980, A&A, 86, 163) have considered plasma instabilities with reference to the Crab, and Laing (1980, MNRAS, 193, 439) has modelled the magnetic-field configuration in the filaments. Kochhar (1979, Nature, 277, 116) has proposed that the nebula was produced by the disruption of a helium star.

The radio emission from Cas A has been modelled by Shirkey (1979, Ap.J., 232, 826), and Cowsik and Sarkar (1980, MNRAS, 191, 855) have deduced that the magnetic field in the Cas A shell must exceed 8 x 10^{-5}G. The mass in the remnant is estimated to exceed 10 $M_\odot$ by Brecher and Wasserman (1980, Ap.J.Lett., 240,L105). Johnston and Joss (1980, Ap.J., 242, 1124) interpret the abundances of the fast-moving Cas A knots in terms of nucleosynthesis models. Shklovsky (1979, Nature, 279, 703) and Kundt (1980, Nature, 284, 191) have discussed whether the remnant contains a black hole.

The relationship between galactic γ-ray sources and SNRs is still unclear, any detailed interpretation being hampered by the poor resolution of current γ-ray surveys. Possible γ-ray emission in SNRs from pion decay has been discussed by Montmerle (1979, Ap.J., 231, 95), Cavallo and Pacini (1980, A&A, 88, 367), and Cowsik and Sarkar (1980, "Non-Solar Gamma Rays", 57). Montmerle (op. cit) and Montmerle and Cesarsky (1980, "Non-Solar Gamma Rays", 61) argue that the γ-ray sources are correlated with SNRs situated near OB associations (SNOBs), implying that only such SNRs generate cosmic rays. Possible associations between γ-ray sources and SNRs have been investigated by van den Bergh (1979, A.J., 84, 71), Panagia and Zamorani (1979, A&A, 75, 303), and Rothenflug and Caraveo (1980, A&A, 81, 218). The only two well-identified γ-ray sources in SNRs, the Vela and Crab pulsars, are the subjects of papers by Ochelkov and Usov (1980, Pis'ma Astron. Zh., 6, 414) and White et al. (1980, Nature, 284, 608). Ling et al. (1979, Ap.J., 231, 896) have reported a possible γ-ray line feature from the Crab Nebula. Morfill et al. (1981, Ap.J., 246, 810) attribute the source CG 353+16 to an SNR shock (North Polar Spur) interacting with the ρ Oph cloud. Perhaps the most interesting γ-ray result to appear has been the detection (see Evans et al. 1980, Ap.J.Lett., 237, L7) of a γ-ray burst from the SNR N49 in the LMC. Ramaty et al. (1980, Nature, 287, 122) attribute this to a vibrating neutron star in the remnant.

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In the past three years, X-ray observations of SNRs have been yielding a wealth of new data, especially from HEAO-1 and HEAO-2 (Einstein Observatory). Some of these and other recent X-ray results are presented in "X-ray Astronomy", Proc. NATO Adv. Study Institute held at Erice, Italy in 1979. The state of X-ray observations at the beginning of the period reviewed here is discussed by Zarnecki (1979, Proc. Roy. Soc. A., 366, 311).

The hard X-ray structure of the Crab Nebula has been studied by Makishima et al. (1980, Bull. Inst. Sp. Aero. Sci. Univ. Tokyo B, 16, 1033) and limits on line emission, and hence thermal emission, have been given by Schattenburg et al. (1980, Ap.J.Lett., 241, L151) and Pravdo and Serlemitsos (1981, Ap.J., 246, 484). Charles et al. (1979, Ap.J.Lett., 230, L83) have presented evidence of an inter-stellar oxygen edge in the spectrum. The X-ray structure of Cas A has been studied by Murray et al. (1979, Ap.J.Lett., 234, L69) and by Fabian et al. (1980, MNRAS, 193, 175); the latter authors deduce a remnant mass exceeding 15 $M_\odot$. Pravdo and Smith (1979, Ap.J.Lett., 234, L195) have detected a high-temperature component in Cas A (and Tycho), indicating electron-ion temperature equilibrium. The X-ray spectrum of Cas A has been analysed by Becker et al. (1979, Ap.J.Lett., 234, L73). The structure of Tycho's SNR has been observed by Fabbiano et al. (1980, Ap.J.Lett., 235, L163), while its X-ray line emission is discussed by Pravdo et al. (1980, Ap.J.Lett., 235, L9). Becker et al. (1980, Ap.J.Lett., 235, L5) have analysed the abundances indicated by the line emission, although Arnett (1980, Ap.J., 240, 105) has warned that one must consider the effect of abundance inhomogeneities in young remnants. X-ray emission from Kepler's SNR has finally been detected (Tuohy et al., 1979, Nature, 279, 139) and its spectrum has been observed by Becker et al. (1980, Ap.J.Lett., 237, L77).

X-ray images of the Puppis A SNR (and IC 443)have been obtained by Levine et al. (1979, Ap.J.Lett., 228, L99) and its line emission has been analysed by Winkler et al. (1981, Ap.J., 245, 574; 1981, Ap.J.Lett., 246, L27). Canizares and Winkler (1981, Ap.J.Lett., 246, L33) deduce abundances which indicate a massive type II supernova progenitor. Itoh (1979, Nature, 281, 656) has commented on the effects of ionization non-equilibrium in this object. X-ray maps of the Vela SNR have been presented by Hearn et al. (1980, Ap.J.Lett., 235, L67). The X-ray structure of the Cygnus Loop has been investigated by Rappaport et al. (1979, Ap.J., 227, 285), Tuohy et al. (1979, Ap.J.Lett., 234, L101) and Gronenschild (1980, A&A, 85, 66), while its X-ray spectrum has been studied by Kayat et al. (1980, MNRAS, 191, 729) and Kahn et al. (1980, Ap.J.Lett., 242, L19). Charles et al. (1981, Ap.J.Lett., 246, L121) have observed X-ray line emission from IC 443. The X-ray features of the North Polar Spur, thought to be an old SNR, have been discussed by Hayakawa et al. (1979, Publ. Astron. Soc. Japan, 31, 71), Inoue et al. (1980, Ap.J., 238, 886), Iwan (1980, Ap.J., 239, 316), and Davelaar et al. (1980, A&A, 92, 231).

Other galactic SNRs for which new X-ray data have become available are G21.5-0.9 (plerion) - Becker and Szymkowiak (1981, Ap.J.Lett., 248, L23); G62.1-11.2 (possible old remnant seen only in X-rays) - Stern et al. (1980, Ap.J.Lett., 238, L77); G65.2+5.7 (recently discovered old remnant in Cygnus) - Mason et al. (1979, Ap.J.Lett., 230, L163); G74.9+1.2 (CTB 87, plerion) - Wilson (1980, Ap.J.Lett., 241, L19); G109.1-1.0 (possible W50/SS433 object) - Gregory and Fahlman (1980, Nature, 287, 805); G132.4+2.2 (HB 3) and 3C 58 - Galas et al. (1980, Ap.J.Lett., 236, L13); G160.5+2.8 (HB 9) - Tuohy et al. (1979, MNRAS, 189, 59P); G292.0+1.8 (MSH 11-54, possible plerion) - Agrawal and Riegler (1980, Ap.J.Lett., 237, L33) and Clark et al. (1980, MNRAS, 193, 129); G296.1-0.7 and G296.2-0.5 (new X-ray remnant, also seen optically by Hutchings et al. 1981, A.J., 86, 871) - Markert et al. (1981, Ap.J.Lett., 248, L17); G296.5+10.0 (PKS 1209-52) and G332.4-0.4 (RCW 103,see also Tuohy and Garmire, Ap.J.Lett., 239, L107) - Tuohy et al.(1979, Ap.J.Lett., 230, L27); G327.6+14.0 (SN 1006) - Zarnecki and Bibbo (1979, MNRAS, 186, 51P), Becker et al. (1980, Ap.J.Lett., 240, L33), and Pye et al. (1981, MNRAS, 194, 569); and G339.9+18.3 (possible old SNR seen only in X-rays)- Riegler et al. (1980, Ap.J.Lett. 235, L71). The Lupus region, containing the SN 1006 remnant and the Lupus Loop, has been surveyed by Winkler et al. (1979, Ap.J.Lett., 229, L123), Davelaar et al. (1979, Ap.J., 230, 428), and by Toor (1980, A&A, 85, 184). Of course one of the more exciting discoveries has been that of jets emanating from the object SS433 in W50 (Seward et al. 1980, Nature, 287, 806).

Two large X-ray features that may be old remnants (singly or collectively) are the Cygnus "superbubble" (Cash et al. 1980, Ap.J.Lett., 238, L71; Higdon, 1981, Ap.J., 244, 88) and the Monogem Ring (Nousek et al. 1981, Ap.J., 248, 152). Gronenschild (1979, A&A, 77, 53) has discussed ANS observations, setting upper limits on the X-ray luminosity of several remnants, and Lamb and Markert (1981, Ap.J., 244, 94) have detected X-ray emission from three SNRs near the γ-ray sources CG 327-0 and CG 333+0. Observations of X-ray emission from SNRs in the LMC have been reported by Long and Helfand (1979, Ap.J.Lett., 234, L77) and McKee et al. (1980, Ap.J., 238, 93). Over a dozen X-ray SNRs have now been detected in the LMC.

Optical and UV observations of SNRs have been stimulated by the availability of shock-excitation models for interpretation and especially by the UV observational capability provided by IUE. Wu (1981, Ap.J., 245, 581) has analysed ANS observations of the spectrum of the Crab Nebula and Davidson (1979, Ap.J., 228, 179) has studied the emission-line spectra of condensations in the remnant. Schmidt et al (1979, Ap.J., 227, 106) have mapped the small-scale optical polarization in portions of the nebula.

Chevalier and Kirshner (1979, Ap.J., 233, 154) have derived abundance inhomogeneities in Cas A, and Sakhibov (1980, Pis'ma Astron. Zh., 6, 101) has analysed the expansion of the shell of this remnant. The spectrum of Kepler's SNR has been observed by van den Bergh (1980, A&A, 86, 155), while Danziger and Goss (1980, MNRAS, 190, 47p) have redetermined its distance, finding it to be much closer than had been previously adopted. Coronal-line emission from several SNRs has been used as a tracer of hot plasma: Puppis A (Lucke et al. 1979, Ap.J., 228, 763; Clark et al. 1979, MNRAS, 188, 11p), Cygnus Loop (Lucke et al. 1980, Ap.J., 235, 882), IC 443 (Woodgate et al. 1979, Ap.J.Lett., 229, L119), and Magellanic Cloud SNRs (Dopita and Mathewson, 1979, Ap.J.Lett., 231, L147).

The UV spectrum of the Vela SNR has been studied by Danziger et al. (1980, MNRAS, 192, 83P) and by Raymond et al. (1981, Ap.J., 246, 100) who have interpreted it in terms of radiative-shock models. The UV spectra of filaments in the Cygnus Loop have been observed by Benvenuti et al. (1979, Nature, 277, 99; 1979, Mem. Soc. Astron. Italiana, 50, 197), Shemansky et al. (1979, Ap.J., 231, 35), Raymond et al. (1980, Ap.J., 238, 881), and D'Odorico et al. (1980, A&A, 92, 22). Optical spectra of the Cygnus Loop have been analysed by Raymond et al. (1980, Ap.J.Lett., 238, L21) and by Contini et al. (1980, A&A, 92, 273). High-velocity gas and filaments in IC 443 have been investigated optically by Lozinskaya (1979, A&A, 71, 29), Bychkov and Lebedev (1979, A&A, 80, 167), and Fesen and Kirshner (1980, Ap.J., 242, 1023). Kirshner and Arnold (1979, Ap.J., 229, 147) have studied the kinematics of the evolved remnant S147 and Phillips et al. (1981, MNRAS, 195, 485) have detected high-velocity gas in this SNR.

Because of the discovery of the enigmatic object SS433 in the galactic remnant W50, the latter has been studied extensively: Murdin and Clark (1980, MNRAS, 190, 65P), van den Bergh (1980, Ap.J.Lett., 236, L23), Zealey et al. (1980, MNRAS, 192, 731), Shuder et al. (1980, PASP, 92, 259), and Kirshner and Chevalier (1980, Ap.J. Lett., 242, L77). The optical spectrum of the recently identified SNR G109.1-1.0, which in some respects resembles W50/SS433, has been observed by Blair and Kirshner (1981, Nature, 291, 132).

Other galactic remnants for which new optical observations have been obtained are G69.0+2.7 (the peculiar remnant CTB 80) - Angerhofer et al. (1980, Ap.J., 236, 143); G119.5+10.0 (CTA 1) - Fesen et al. (1981, Ap.J., 247, 148); G126.2+1.6 - Blair et al. (1980, Ap.J., 242, 592); G130.7+3.1 (3C 58) - Panagia and Weiler (estimate of extinction) (1980, A&A, 82, 389); G132.4+2.2 (HB 3) - Lozinskaya and Sitnik (1980, Astron. Zh., 57, 997); G166.2+2.5 (OA 184) - Lozinskaya and Sitnik (1979, Pis'ma Astron. Zh., 5, 348); G286.8-0.5 (Carina SNR) - Elliott (1979, MNRAS, 186, 9P); G290.1-0.8 - Kirshner and Winkler (1979, Ap.J., 227, 853) and Elliott and Malin (1979, MNRAS, 186, 45P); G292.0+1.8 (Crab-like remnant?) - Goss et al. (1979, MNRAS, 188, 357), Murdin and Clark (1979, MNRAS, 189, 501), and van den Bergh (1979, Ap.J., 234, 493); G315.4-2.3 (RCW 86) - Ruiz (1981, Ap.J., 243, 814); G326.3-1.8 (MSH 15-56) - van den Bergh (1979, Ap.J., 227, 497), and Dennefeld (1980, PASP, 92, 603); G327.6+14.0 (SN 1006) - Schweizer and Middleditch (discovery of central blue star) (1980, Ap.J., 241, 1039) and Lasker (1981, Ap.J., 244, 517); and G339.2-0.4 (probably not an SNR) - Murdin et al. (1979, MNRAS, 189, 459).

Lozinskaya (1980, A&A, 84, 26; 1980, Astron. Zh., 57, 1197) has discussed interferometric observations of several old remnants, and Zealey et al. (1979, A&A Suppl., 38, 39) have reported on a sensitive search for optical remnants. Fesen et al. (1979, Ap.J., 234, 174) have searched unsuccessfully for stellar remnants in six well-known SNRs, while van den Bergh (1980, JAA, 1, 67) finds no excess of OB stars within SNRs. Van den Bergh (1978, PASP, 90, 669) has found no nebulosity near the "guest star" of 393 AD, and has discussed whether the peculiar remnant CTB 80 may be the result of a supernova in 1408 AD (1981, PASP, 92, 768). A possible observation of the Cas A supernova by Flamsteed has been discussed by Ashworth (1980, J. Hist. Ast., 11, 1), Kamper (1980, The Observatory, 100, 3) and Broughton (1979, J. Roy. Astron. Soc. Can., 73, 381).

Studies of extragalactic SNRs have become possible with improvements in instrumentation. D'Odorico et al. (1980, A&A Suppl., 40, 67) have compiled a catalogue of SNR candidates in nearby galaxies. Observations of Magellanic Cloud SNRs have been reported by Lasker (1979, PASP, 91, 153; 1981, PASP, 93, 422; (N 132 D) 1980, Ap.J., 237, 765), Dopita (1979, Ap.J.Suppl., 40, 455), Benvenuti et al. (N49, N63) (1980, Ap.J., 238, 601), van den Bergh and Dufour (mass of N63A supernova) (1980, PASP, 92, 32), Mathewson et al. (oxygen-rich remnant) (1980, Ap.J.Lett., 242, L73), Meaburn and Terrett (N51 D) (1980, A&A, 89, 126), Blades et al. (N70) (1980, MNRAS, 192, 101), Rosado et al. (kinematics of N70) (1981, A&A, 97, 342), and Danziger et al. (30 Dor B SNR) (1981, MNRAS, 195, 33P). Remnants in M31 have been observed spectroscopically by Dennefeld and Kunth (1981, A.J., 86, 989) and Blair et al. (1981, Ap.J., 247, 879), while Sabbadin and Bianchini (1979, PASP, 91, 62), Sabbadin (1979, A&A, 80, 212), Sabbadin et al. (1980, A&A Suppl., 39, 97), and Benvenuti et al. (1979, Astrophys. Space Sci., 66, 39) have listed SNRs in M33. Some of these have been observed spectroscopically by Danziger et al. (1979, MNRAS, 186, 555) and by Dopita et al. (1980, Ap.J., 236, 628). Spectral observations by Kirshner and Blair (1980, Ap.J., 236, 135) confirm that the extraordinary SNR in NGC 4449 is similar to Cas A.

It has been predicted that infrared emission from condensates formed in supernovae should be detectable in young SNRs (Dwek and Werner, 1981, Ap.J., 248, 138). Observations of young remnants, however, have yielded no detections (Harvey et al. 1978, PASP, 90, 655; Wright et al. 1980, Ap.J.Lett., 240, L157). Grasdalen (1979, PASP, 91, 436) shows that the near-infrared emission from the Crab fits the extrapolated optical continuum. It is predicted that interstellar grains swept up by an SNR shock or contained in evaporating clouds within SNRs should be detectable in the far infrared (see Section 5 for references). Campbell et al (1981, Ap.J., 247, 530) may have detected such emission from G78.2+2.1.

Radio data on SNRs is slowly expanding as more and more low-surface-brightness SNRs are mapped, especially by the Effelsberg telescope in the northern hemisphere and the Fleurs synthesis telescope in the southern. Detailed observations of the

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filamentary structure of the Crab Nebula have been presented by Swinbank and Pooley (1979, MNRAS, 186, 775) and Wright and Forster (1980, Ap.J., 239, 873), and have been analysed by Swinbank (1980, MNRAS, 193, 451). Millimetre and sub-millimetre measurements of the Crab spectrum are reported by Wright et al. (1979, Nature, 279, 703). Flett and Henderson (1979, MNRAS, 189, 867) have made polarization measurements of the Crab and Cas A, and Dmitrenko et al. (1981, Radiofiz., 24, 14) report on absolute flux measurements of these sources. Variability of the radio emission of the Crab Nebula is discussed by Tseitlin et al. (1981, Radiofiz., 23, 996). The compact source in the Crab has been studied by Bovkun (1979, Astron. Zh., 56, 699), Bobeiko et al. (1979, Astrophys. Space Sci., 66, 211), and Maloney and Gottesman (1979, Ap.J., 234, 485), using occultation techniques. The latter (1981, PASP, 93, 518) propose a cooperative network for future occultation observations.

The secular decrease in the radio emission from Cas A has been observed by Vinyajkin et al. (1979, Pis'ma Astron. Zh., 5, 450; 1980, Pis'ma Astron.Zh., 6, 620), and Vinyajkin and Razin (1979, Astron. Zh., 56, 913). This decrease has been interpreted by Cowsik (1979, Ap.J., 227, 856), Fedorenko (1979, Astron.Zh., 56, 1235) and Lerche and Caswell (1979, Proc. Astron. Soc. Aust., 3, 347). Structural changes in the radio emission have been analysed by Dickel and Greisen (1979, A&A, 75, 44). Perhaps the most interesting new result has been the detection of a compact scintillating source in Cas A (Bovkoon and Zhouck, 1981, Astrophys. Space Sci., 79, 181).

Klein et al. (1979, A&A, 76, 120) and Henbest (1980, MNRAS, 190, 833) have observed the radio structure of Tycho's SNR, and Lerche and Caswell (1979, A&A, 77, 117) have analysed its turbulent structure. The secular decrease of Tycho's flux density has been measured by Dickel and Spangler (1979, A&A, 79, 243). A small radio source near the centre of the remnant has been reported by Gull and Pooley (1980, IAU Circ. 3502); no corresponding optical object has been detected (Morbey and van den Bergh, 1980, IAU Circ. 3511). The polarization structure of the Vela SNR has been mapped by Milne (1980, A&A, 81, 293) and the rotation measures have been analysed by Lerche and Milne (1980, A&A, 81, 302). Observations at several frequencies of the evolved SNR S147 have been reported by Sofue et al. (1980, Publ. Astron. Soc. Japan, 32, 1), Kundu et al. (1980, A&A, 92, 225), and Angerhofer and Kundu (1981, A.J., 86, 1003).

The unusual SNR containing SS433, W50, has been the subject of papers by Geldzahler et al. (1980, A&A, 84, 237) and Downes et al. (1981, A&A, 97, 296), while observations of the compact source related to SS433 are reported by Seaquist et al. (1979, A.J., 84, 1037), Spencer (1979, Nature, 282, 483), Gilmore and Seaquist (1980, A.J., 85, 1486), Gilmore et al. (1981, A.J., 86, 864) and Hjellming and Johnston (1981, Ap.J.Lett., 246, L141).

Other galactic SNRs for which new radio data have been obtained are G31.9+0.0 (3C 391) - Goss et al. (1979, A&A, 78, 75); G40.5-0.5 (new SNR) - Downes et al. (1980, A&A, 92, 47); G65.2+5.7 (remnant in Cygnus) - Reich et al. (1979, A&A, 72, 270); G69.0+2.7 (CTB 80) - Strom et al. (1980, Nature, 284, 38.); G74.0-8.6 (Cygnus Loop) - Sastry et al. (1981, JAA, 2, 339); G78.2+2.1 (possible scintillating source) - Cordes and Dickey (1979, Nature, 281, 24); G84.2-0.8 - Matthews and Shaver (1980, A&A, 87, 255); G93.3+6.9 (DA 530, highly polarized) - Haslam et al. (1980, A&A, 92, 57); G109.2-1.0 (new SNR) - Hughes et al. (1981, Ap.J.Lett., 246, L127); G117.3+0.1 (CTB 1) - Dickel and Willis (1980, A&A, 85, 55) and Reich and Braunsfurth (1981, A&A, 99, 17, who also report the discovery of two new SNRs); G119.5+10.2 (CTA 1) - Sieber et al. (1979, A&A, 74, 361); G126.2+1.6 (new SNR) - Reich et al. (1979, A&A, 78, L13); G130.7+3.1 (3C 58) - Weiler (1980, A&A, 84, 271); G339.2-0.4 (probably not an SNR) - Shaver et al. (1980, MNRAS, 190, 527); and G359.1-0.5 (possible new SNR) - Downes et al. (1979, A&A Suppl., 35, 1).

Rossano et al. (1980, A.J., 85, 716) have found no evidence of an SNR in the

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W1 region, while Bonsignori-Facondi and Tomasi (1979, A&A, 77, 93) have evidence of six new SNRs, with one in the W1 region. Goss and Morris (1980, JAA, 1, 189) have failed to detect a remnant near the third youngest pulsar. The new Fleurs observations of SNRs are reported by Milne et al. (1979, MNRAS, 188, 437) and Caswell et al. (1980, MNRAS, 190, 881; 1981, MNRAS, 195, 89). Reich and Steffen (1981, A&A, 93, 27) have presented new continuum observations of galactic Loop IV, a possible SNR. Palumbo et al. (1980, Acta Astron. Sinica, 21, 334) have unsuccessfully searched for radio emission from ancient "guest stars". Compact sources in the direction of SNRs are discussed by Geldzahler and Shaffer (1981, Ap.J., 248, 132).

Line observations (21-cm) of neutral hydrogen associated with SNRs have been discussed in Section 3. Distances to some SNRs or related objects have been determined from H I absorption studies, including Tycho's SNR (Schwarz et al. 1980, MNRAS, 192, 67P), G46.8-0.3 (Sato, 1979, Ap.Lett., 20, 43), CL 4 (in Cygnus Loop) (Goss et al. 1979, A&A, 73, L17; Payne and Bania, 1979, A.J., 84, 611), and SS433 (in W50) (van Gorkom et al. 1980, A&A, 82, L1). Radio observations of extragalactic SNRs have been made by: LMC - Milne et al. (1980, MNRAS, 191, 469); M33 - Goss et al. (1980, MNRAS, 193, 901) and NGC 4449 - de Bruyn et al. (1981, A&A, 94, L25). Searches for emission from extremely young (<50 years) SNRs have been reported by Ulmer et al. (1980, Nature, 285, 151), Weiler et al. (1981, Ap.J.Lett., 243, L151), and Pacini and Salvati (1981, Ap.J.Lett., 245, L107).

References to several observations of molecular species in shocked gas within SNRs are given in Section 4. Slysh et al. (1980, IAU Symp. No. 87, 473) have found that W28 and W44 are probably interacting with molecular clouds, but Wootten (1981, Ap.J., 245, 105) finds no evidence of SNR-induced star formation in W28, nor do Wynn-Williams et al. (1981, A.J., 86, 565) for W44. Singh and Naranan (1979, Astrophys. Space Sci., 66, 191) have suggested that supernova-induced star formation has occurred in the Mon OB2 association.

Statistical analyses of the surface brightness versus diameter distribution of radio SNRs have been revised allowing, for example, for the effects of ambient density variations from remnant to remnant. Lerche (1980, A&A, 85, 141) and Gobel et al. (1981, A&A, 93, 43) have examined the relationship between radio spectral index and other properties of SNRs. Caswell and Lerche (1979, MNRAS, 187, 201), have investigated the dependence of surface brightness on height above the galactic plane, and Milne (1979, Aust. J. Phys., 32, 83) has presented a new catalogue of galactic SNRs based on such corrections. Lozinskaya (1981, Pis'ma Astron. Zh., 7, 29) gives a new calibration of the surface brightness/diameter relation.

Comparisons of SNR and pulsar distributions and birth rates, based in some cases on the assumption that many SNRs expand rapidly into a tenuous hot interstellar medium, have been presented by Lozinskaya (1979, Astron. Zh., 56, 900), Wielebinski (1979, IAU Symp. No. 84, 113), Kimeridze (1980, Pis'ma Astron. Zh., 6, 742), Kafatos et al. (1980, Ap.J., 242, 294) and Tomisaka et al. (1980, Prog. Theor. Phys. Japan, 64, 1587). The discrepancies between the supernova rate, and SNR and pulsar birth rates seem to be disappearing. However, it will probably be some time before the morphological differences of galactic SNRs are clearly understood.

10. Interstellar Lines

(D.C.V. Mallik)

The (2-0) Phillips band of C_2 near λ8760 has been detected in absorption in VI Cyg 12, ζ Oph, ζ and ο Per (Hobbs, 1979, Ap.J. Lett., 232, L175 and 1981, Ap.J., 243, 485; Chaffee et al. 1980, Ap.J., 236, 474). From an analysis of the rotational fine-structure lines seen in ζ and ο Per column densities of C_2 in the

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range 1.4 - 2.0 x 10^{13} cm^{-2} and T_{exc} ∿ 100K are obtained, typical of the diffuse clouds. Hobbs (1979, Ap.J.Lett., 229, L129) has also reported high-resolution observations of Ti II λ3384 toward ζ Per. Na I, K I and Ca II lines have been studied in the spectra of HD 72127, ι^1Sco, 102 Her and 6 Cas (Hobbs, 1979, PASP, 91, 690). Line components showing strikingly large values of N(Ca II)/N (Na I)(>5) are seen in HD 72127. Blades et al. (1980, MNRAS, 193, 849) have obtained the highest resolution data as yet on interstellar Na I. With an improvement of nearly a factor of three over Hobbs, they resolved 7 individual clouds in the line-of-sight to α Cyg and also saw the Na I $^2S_{1/2}$ hyperfine splitting in 3 of these. Their major conclusion is that the Na I lines are considerably narrower than thought previously.

The capabilities of IUE have been discussed by Jenkins (1980, NASA-CP, 2171, 541) and many of the results obtained with it have been reviewed in the proceedings of IUE symposia (1980, NASA-CP, 2171; 1980, Second European IUE Conference, ESA SP-157). The early detection by IUE of strong galactic C IV and Si IV absorptions in the spectra of two hot stars in the LMC (Savage and de Boer, 1979, Ap.J.Lett., 230, L77) was interpreted as observational evidence for a hot gaseous galactic corona. For a discussion see § 2. Further observations (de Boer and Savage, 1980, Ap.J., 238, 86) suggested the existence of a corona around the Magellanic Clouds.

Ferlet et al. (1980, Ap.J., 235, 478; 242, 576) analysed the UV data obtained with Copernicus in the line-of-sight to γ Cas. Four components of interstellar N I were detected. The principal component (V = -17.1 km s^{-1}) contains almost all the N(N) and is warm (T ≃ 12000K). Column densities in O I, D I, Ar I and in H_2 (J = 0 and J = 3) were also determined. They detected no depletion of N, O and Ar and found D/H = 1.3 x 10^{-5} to within 20%. Frisch (1979, Ap.J., 227, 474; 1980, Ap.J., 241, 697) has studied the χ Oph line-of-sight both in the visible and in UV. Shull (1980, Ap.J., 238, 560) has reported the detection of a high-velocity O VI feature towards 15 Mon and finds no depletion of Si or other refractory elements in the intermediate velocity component. Meneguzzi and York (1980, Ap.J.Lett., 235, L111) have detected B II λ1362 in front of κ Ori and deduced an abundance consistent with the theory of production of boron by cosmic rays in the ISM. D/H has been measured towards δ, ε and ι Ori by Laurent et al. (1979, Ap.J., 229, 923). The O I depletion in the diffuse ISM has been discussed by de Boer (1981, Ap.J., 244, 848). Savage and Bohlin (1979, Ap.J., 229, 136), from a study of Fe II resonance lines toward 55 hot stars, find a large and variable depletion of gaseous iron, correlating roughly with variations in the UV extinction.

ζ Oph with its unusually rich interstellar spectrum has been the subject of several papers: Snow and Meyers (1979, Ap.J., 229, 545); de Boer (1979, Ap.J., 229, 132); Snow et al. who also discuss Copernicus observations toward ξ Per (1979, Ap.J., 234, 506); de Boer and Morton (1979, A&A, 71, 141); Snow and Dodgen (1980, Ap.J., 237, 708). Snow and York (1981, Ap.J. Lett., 247, L39) have reported the detection of interstellar Fℓ toward δ Sco. Snow and Jenkins (1980, Ap.J., 241, 161) have analysed UV data on six stars in the ρ Oph cloud complex and concluded that the first ions of the heavy elements form in a comparatively dilute outer region with low depletion, and that the cloud core "has a small velocity dispersion or is either strongly depleted or dense". Bohm-Vitense (1981, Ap.J., 244, 504) has found interstellar Mg II lines in high-resolution IUE spectra of several nearby F and G stars with large rotations. The lines occur as narrow absorptions in the centres of k_2 and h_2 chromospheric emission. Bates et al. (1979, A&A, 71, L22) have obtained balloon UV interferometric scans of interstellar Mg I toward ζ Ori.

Stars in the Ori OB1 association have been observed in UV (Cowie et al. 1979, Ap.J., 230, 469; Shull, 1979, Ap.J., 233, 182) and show intermediate-velocity components expanding away from the stars. The moderately high ionization, low density, low metal depletion and dynamics of these clouds may be attributed to repeated action of supernovae in a patchy low-density region of the ISM. Wallerstein et al. (1980, Ap.J., 240, 834) analyzed UV and optical data on the interstellar gas in the Gum Nebula and concluded that the observations were consistent with a model of the nebula as an H II region ionized by OB stars and stirred up by multiple winds. High velocity gas has also been detected in C IV and Si IV toward two stars in the I Per OB association (Phillips and Gondhalekar, 1981, MNRAS, 196, 533). Jenkins et al. (1981, Ap.J., 248, 977) have discussed the UV data on HD 72350 and other stars behind the Vela SNR. The strong statistical correlation of excited C I lines seen in many stars with the high velocity C IV suggests the presence of shocks and action of SN blast waves in an inhomogeneous medium.

The line-of-sight to 30 Dor in LMC was observed in the visible by Blades (1980, MNRAS, 190, 33) and Blades and Meaburn (1980, ibid., 59P) and in UV by de Boer et al. (1980, Ap.J., 236, 769). Blades (1981, MNRAS, 196, 65P) also observed interstellar Ca II in the spectrum of the 1980 SN in NGC 1316. Clouds at heliocentric velocities of +18, +1364 and +1886 km s^{-1} were detected with the lowest one being in our Galaxy and the high-velocity weaker ones presumably arising in NGC 1316.

Songaila and York (1980, Ap.J., 242, 976) and Songaila et al. (1981, Ap.J., 248, 956) have reported on a high-resolution optical survey of interstellar lines toward globular clusters and extragalactic objects. Na I and Ca II absorptions by gas in the Magellanic Stream are observed in the spectrum of Fairall 9 (Songaila, 1981, Ap.J.Lett., 243, L19). Optical data (Songaila, 1981, Ap.J., 248, 945) towards the Magellanic Clouds confirm the existence of the two absorption components at LSR velocities of 60 and 120 km s^{-1} discovered first in UV. These features are interpreted as condensations formed by radiative cooling of a coronal halo gas.

Savage and Jeske (1981, Ap.J., 244, 768) have compared the absorption features formed in the haloes of our Galaxy and the Magellanic Clouds with high dispersion spectra of quasar absorption line systems and have noted remarkable similarities. They hazard the guess that many of the absorption line systems present in the spectra of quasars have been produced in the gaseous haloes of intervening galaxies. Cowie et al. (1981, Ap.J., 246, 653) have observed Ca II K and Na I D lines in the spectrum of 3C 273 and compared the velocity structure in the line-of-sight with existing 21-cm emission and absorption line data. They detect two warm substantially ionized regions ($T \sim 1000$-8000K) and suggest that the strong UV lines seen by IUE in the quasar spectrum arise in this medium. The interpretation of the C IV line seen in the spectrum of the quasar, however, is not clear.

X-ray emission-line observations by HEAO 1 of IC 443 (Charles et al. 1981, Ap.J.Lett., 246, L121) and Tycho (Pravdo et al. 1980, Ap.J.Lett., 235, L9) have been used to derive abundances of Fe, Si and S. Observations by HEAO 2 of Cas A (Becker et al. 1979, Ap.J.Lett., 234, L73), Tycho (Becker, et al. 1980, Ap.J.Lett., 235, L5), Kepler (Becker et al. 1980, Ap.J.Lett., 237, L77), G292.0+1.8 (Clark et al. 1980, MNRAS, 193, 129) and Puppis A (Winkler et al. 1981, Ap.J.Lett., 246, L27; Canizares and Winkler, 1981, Ap.J.Lett., 246, L33) have thrown light on abundances of O, S, Ar, Ca, H, N, Ne, Fe, Si and Mg. The abundances of Fe and Mg are slightly less than solar but, Si, S and Ar are each in excess of solar and appear to go in the ratio 1:2:4 (Holt, 1979, X-Ray Astronomy, D. Reidel). Analyses of the above observations suggest that in Cas A the fast-moving knots appear to be highly enriched in O, S, Ar and Ca and deficient in H and N, while the slower moving material shows an overabundance of He and N. In Puppis A, the ratios of abundances of O and Ne to Fe appear to be 3 and 5 times their cosmic value. However, Holt (op. cit.) cautions that these "abundances" are model dependent.

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