

DIVISION VI

INTERSTELLAR MATTER

MATIÈRE INTERSTELLAIRE

Division VI provides a focus for astronomers studying a wide range of problems related to the physical and chemical properties of interstellar matter in the Milky Way and other galaxies.

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DIVISION VI COMMISSIONS

Commission 34

Interstellar Matter

DIVISION VI WORKING GROUPS

Division VI WG

Astrochemistry

Division VI WG

Planetary Nebulae

TRIENNIAL REPORT 2009-2012

1. Introduction

Division VI, consisting of one Commission (Commission 34) and two Working Groups (Astrochemistry WG and Planetary Nebulae WG), has 972 members whose theoretical, observational, and experimental research interests cover a wide spectrum of activities associated with the study of the interstellar medium (ISM) in the Universe. As such, the Division has close links with Division VIII, IX, and X. The ISM and stars, the two major visible components of a galaxy, are coupled to each other through star formation, stellar feedback, and gravitational potential; thus, the Division is also closely linked to Division VII.

Our report on activity since 2009 is divided into four sections, covering our view of past and future developments of the Division, important meetings and conferences, relevant proceedings and monographs, and a list of important review articles published in the reporting period. Reports of the Working Groups are provided separately.

2. Developments

2.1. *Scientific advances*

Recent advances in observing facilities have made it possible to study the physical structure and processes of the interstellar medium in the Galaxy and nearby galaxies with higher angular resolution in a wide range of wavelengths. Most notably, the dust component of the interstellar medium can be studied with unprecedented sensitivity and angular resolution in mid- to far-infrared by the Spitzer Space Telescope, the Herschel Space Observatory, and the Planck Satellite. Numerous surveys were made for the Galactic plane, e.g. Spitzer's GLIMPSE and MIPS GAL, and Herschel's Hi-GAL, and for the Magellanic Clouds, e.g. SAGE and S³C. These surveys have been used to analyze the abundance and distribution of polycyclic aromatic hydrocarbons, very small grains, and big grains. Planck, in addition to its mission goal in cosmology, mapped the coldest dust in the Galaxy. Besides these large-scale mappings, Spitzer and Herschel observations have been used to discover molecules, e.g. fullerenes, and study astrochemistry.

From the ground, the International Galactic Plane Survey (IGPS) combines many radio telescope surveys from around the world to map the interstellar gas and dust in the galaxy, while the HI Nearby Galaxy Survey (THINGS) maps out the interstellar gas in nearby galaxies. The Bolocam Galactic Plane Survey (BGPS) and the APEX Telescope Large Area Survey of the Galaxy (ATLASGAL) are mapping out the colder dust in the Galaxy. The Atacama Large Millimeter Array (ALMA) will provide a clear view of dust and star formation in the Galaxy and nearby galaxies. The polarimetric capabilities of Institut de Radioastronomie Millimétrique (IRAM) in lines, Planck in continuum, and the upcoming ALMA in mm-submm wavelengths are opening a new window to probe magnetic fields. The Wisconsin H α Mapper (WHAM) has mapped the distribution and velocities of warm ionized gas in the Galaxy from the north and is extending to the south.

At the high-energy end, Chandra and XMM-Newton Observatories have been used to investigate the distribution and physical properties of the 10⁶ K hot ionized gas in star forming regions, such as the Carina Nebula, as well as diffuse fields in the Galaxy, Magellanic Clouds, and nearby galaxies. The Far UV Spectroscopic Explorer (FUSE) and the Hubble Space Telescope (HST) STIS and COS have been used to probe the 10⁵ K hot gas at interfaces and in the Galactic halo. The Fermi Gamma-Ray Observatory has resolved the gamma-ray emission and revealed the sites of cosmic-ray production in the Galaxy as well as the Magellanic Clouds, and revealed the existence of huge bubbles in the Galactic Center of mysterious origin.

Progress has also been made in the numerical modeling of local and global conditions of the ISM, its morphology and its time-dependent evolution, owing to a rapid development of suitable hard- and software. It is now possible to follow the full non-linear evolution of a plasma by solving the hydro- or MHD equations in high resolution simulations with adaptive mesh refinement. One of the key results of the past years was to recognize, and quantitatively describe, the role of compressible turbulence in the ISM and its impact on the distribution of gas into phases, the mixing of chemically enriched material, the volume and mass filling factors of the ISM plasma, and its heating and cooling history, amongst others.

Advances have also been made in the treatment of magnetic field in star formation. To address the magnetic flux problem in the collapse of a molecular cloud to form stars, the ambipolar diffuse mechanism was suggested. Recently, an alternative mechanism to transport magnetic flux in the early stage of star formation is proposed – magnetic reconnection in the presence of turbulence. 3-D MHD simulations of ISM clouds with consideration of a gravitational field provided by embedded stars and introducing

turbulence indicate that magnetic reconnections can indeed reduce the magnetic field built up at the center. It has also been shown that, with the considering of effects of the self-gravity in the clouds, the turbulent reconnection transport may be efficient enough to make an initially subcritical cloud that becomes supercritical and collapse. 3-D MHD simulations show that turbulent magnetic reconnection can also transport magnetic flux to the outskirts and form a protostellar disk. (Contributed by E. M. de Gouveia Dal Pino.)

To promote scientific communications and collaborations, the Division has supported or organized several Symposia and Special Sessions, covering topics of ISM in general, star formation, and magnetic fields in the IAU General Assembly at Beijing in August 2012. These Symposia and Special Sessions are listed in Section 3.

2.2. Restructuring of Divisions and Commissions

The Division members are mostly in favor of restructuring the IAU Divisions. It is logical to merge Division VI Interstellar Matter and Division VII Galactic System into Division H. The general concern is the title of Division H. Among the responses, the majority think that the title “Interstellar Matter & Local Universe” can be fine-tuned to better represent the constituents of Division H.

It has been noticed that Laboratory Astrophysics is conspicuously absent in the IAU structure. Laboratory work has made essential contributions to, for example, astrochemistry and plasma astrophysics that are particularly relevant to Commission 34. While there is no specific commission on Laboratory Astrophysics, it should at least be mentioned in “Note b” that states what Division B will cover.

There is also concern that some Commissions in other Divisions are very narrowly focused and may continue to exist for historical purposes. It is questioned whether some small Commissions with similar focus could be merged into a reasonably sized Commission. The draft document for the IAU Restructuring did not provide sizes of membership for the Commissions, making it difficult to judge whether some Commissions might benefit from mergers.

Scientists working on space infrared missions identify themselves more strongly with Division B, and question why Division D is not included in Division B.

Finally, the two Division Working Groups, Astrochemistry and Planetary Nebulae, have both proposed to change their status from Working Group to Commissions. Both Working Groups have organized successful IAU Symposia every ~ 5 years, and both have large numbers of active researchers in the subjects. The Division Organizing Committee fully support these initiatives to convert Astrochemistry and Planetary Nebulae Working Groups to Commissions.

3. Meetings and conferences

Many conferences devoted in whole or in part to the scientific interests of Division members were held in the reporting period. Below, we list some of the most significant meetings:

- *Assembly, Gas Content and Star Formation History of Galaxies*, 21 – 24 September 2009, Charlottesville, Virginia, USA
- *Ten Years of Science with Chandra*, 22 – 25 September 2009, Boston, Massachusetts, USA
- *Planetesimal Formation*, 28 – 30 September 2009, Cambridge, UK
- *Herschel Space Observatory: Discovering the Cold Universe*, 2 – 4 October 2009, Thessaloniki, Greece

- *Interstellar Matter and Star Formation - A Multi-Wavelength Perspective*, 8 – 10 October 2009, Hyderabad, India
- *Reionization to Exoplanets: Spitzer's Growing Legacy*, 26 – 28 October 2009, Pasadena, California, USA
- *2009 Fermi Symposium*, 2 – 5 November 2009, Washington, DC, USA
- *From Circumstellar Disks to Planetary Systems*, 3 – 6 November 2009, Garching, Germany
- *5th Korean Astrophysics Workshop on Shock Waves, Turbulence, and Particle Acceleration*, 18 – 21 November 2009, Pohang, Korea
- *Plasmas in the Laboratory and in the Universe: Interactions, Patterns, and Turbulence*, 1 – 4 December 2009, Como, Italy
- *Infrared Emission, Interstellar Medium and Star Formation*, 22 – 24 February 2010, Heidelberg, Germany
- *Multi-Phase Interstellar Medium and Dynamics of Star Formation*, 28 February – 2 March 2010, Nagoya, Japan
- *Starbursts Near and Far*, 12 March 2010, London, UK
- *From First Light to Newborn Stars: A Science Symposium Celebrating 50 years of our National Observatory*, 14 – 17 March 2010, Tucson, Arizona, USA
- *Galaxies and their Masks - KC Freeman 70th birthday fest*, 11 – 17 April 2010, Namibia
- *Herschel First Results Symposium (44th ESLAB Symposium 2010)*, 4 – 7 May 2010, Noordwijk, The Netherlands
- *Rotation Measure Analysis of Magnetic Fields in and around Radio Galaxies*, 10 – 14 May 2010, Riccione, Italy
- *Magnetic Fields on Scales from Kiloparsecs to Kilometres: Properties and Origin*, 17 – 21 May 2010, Krakow, Poland
- *Magnetic Fields: From Core Collapse to Young Stellar Objects*, 17 – 19 May 2010, London, Ontario, Canada
- *Science with ALMA Band 5 (163 - 211 GHz)*, 24 – 25 May 2010, Rome, Italy
- *IAU Symposium 270: Computational Star Formation*, 31 May – 4 June 2010, Barcelona, Spain
- *PAHs and the Universe: A Symposium to Celebrate the 25th Anniversary of the PAH Hypothesis*, 31 May – 4 June 2010, Toulouse, France
- *Ultraviolet Universe - 2010*, 31 May – 4 June 2010, St. Petersburg, Russia
- *The Dynamic ISM: a celebration of the Canadian Galactic Plane Survey*, 6 – 10 June 2010, Naramata, BC, Canada
- *Cosmic Magnetism - From Stellar to Intergalactic Scales*, 7 – 11 June 2010, Kiama, Australia
- *A Universe of Dwarf Galaxies*, 14 – 18 June 2010, Lyon, France
- *EPoS 2010 The Early Phase of Star Formation*, 14 – 18 June 2010, Ringberg Castle, Germany
- *Asymmetrical Planetary Nebulae V*, 20 – 25 June 2010, Lake District, UK
- *The Multi-Wavelength View of Hot, Massive Stars (39th Liège International Astrophysical Colloquium)*, 12 – 16 July 2010, Liège, Belgium
- *The Infrared/X-ray Connection in Galaxy Evolution*, 12 – 15 July 2010, London, UK
- *New Insights into the Physics of Supernova Remnants and Pulsar Wind Nebulae. 38th COSPAR Scientific Assembly 2010 Event E19*, 18 – 25 July 2010, Bremen, Germany

- *IAU Symposium 272 - Active OB Stars: Structure, Evolution, Mass Loss and Critical Limits*, 19 – 23 July 2010, Paris, France
- *Molecules in Galaxies*, 26 – 30 July 2010, Oxford, UK
- *Astronomy & Astrophysics in Antarctica*, 16–20 August 2010, Xi'an, China
- *Immersion Grating Infrared Spectrometer Science Workshop*, 26 – 27 August 2010, Seoul, Korea
- *25th Summer School and International Symposium on the Physics of Ionized Gases*, 30 August – 3 September 2010, Donji Milanovac, Serbia
- *IAU Symposium 274: Advances in Plasma Astrophysics*, 6 – 10 September 2010, Giardini-Naxos, Italy
- *Herschel and the Formation of Stars and Planetary Systems*, 6 – 9 September 2010, Gothenborg, Sweden
- *Great Barriers in High Mass Star Formation*, 13 – 17 September 2010, Townsville, North Queensland, Australia
- *Conditions and Impact of Star Formation: New Results with Herschel and Beyond*, 19 – 24 September 2010, Zermatt, Switzerland
- *Charge Exchange Meeting*, 29 September 29 – 1 October 2010, Madrid, Spain
- *WittFest: Origins & Evolution of Dust*, 10 – 12 October 2010, Toledo, Ohio, USA
- *Science with the Hubble Space Telescope - III*, 11 – 14 October 2010, Venice, Italy
- *Galaxy Evolution: Infrared to Millimeter Wavelength Perspective*, 25 – 29 October 2010, Guilin, China
- *Stormy Cosmos: The Evolving ISM from Spitzer to Herschel and Beyond*, 1 – 4 November 2010, Pasadena, California, USA
- *Spiral Structure in the Milky Way: Confronting Observations and Theory*, 7 – 10 November 2010, Copiapó, Chile
- *Kinetic Processes in Plasma: Instabilities, Turbulence and Transport*, 8 – 11 November 2010, Bochum, Germany
- *Massive Galaxies Over Cosmic Time 3: The Role of Gas and Dust*, 8 – 10 November 2010, Tucson, Arizona, USA
- *The Submillimeter Universe: The CCAT View*, 12 – 13 November 2010, Ithaca, New York, USA
- *Observing with ALMA: Early Science*, 29 November – 1 December 2010, Grenoble, France
- *Star Formation under Extreme Conditions: the Galactic Center*, 6 – 9 December 2010, Besancon, France
- *The Millimeter and Submillimeter Sky in the Planck Mission Era*, 10 – 14 January 2010, Paris, France
- *ALMA: Extending the Limits of Astrophysical Spectroscopy*, 15 – 17 January 2011, Victoria, BC, Canada
- *Herschel and the Characteristics of Dust in Galaxies*, 28 February – 3 March 2011, Leiden, Netherlands
- *2nd CARMA Symposium*, 28 February – 3 March 2011, Berkeley, California, USA
- *Star Formation across Space and Time: Frontier Science with the LBT and Other Large Facilities*, 31 March – 3 April 2011, Tucson, Arizona, USA
- *Assembling the Puzzle of the Milky Way*, 17 – 22 April 2011, Le Grand-Bornand, France
- *The 5th Korea-Mexico Joint Workshop*, 20 – 22 April 2011, Goheung, Korea
- *A Decade of Exploration with the Magellan Telescopes*, 25 – 28 April 2011, Pasadena, California, USA

- *IAU S280: The Molecular Universe*, 30 May – 3 June 2011, Toledo, Spain
- *Frontier Science Opportunities with the James Webb Space Telescope*, 6 – 8 June 2011, Baltimore, Maryland, USA
- *Star Formation Summer School*, 15 – 18 June 2011, Taipei, Taiwan
- *Cosmic Ray and their Interstellar Environment*, 26 June – 1 July 2011, Montpellier, France
- *Multiwavelength Views of the ISM in High-Redshift Galaxies*, 27 – 30 June 2011, Santiago, Chile
- *From Dust to Galaxies*, 27 – 30 June 2011, Paris, France
- *The X-ray Universe 2011*, 27 – 30 June 2011, Berlin, Germany
- *Recent Advances in Star Formation : Observations and Theory (Part of the Silver Jubilee celebration of the Vainu Bappu Telescope)*, 28 June – 1 July 2011, Bangalore, India
- *EWASS2011 - Special Session SPS2: Massive Stars Formation*, 4 July 2011, Saint-Petersburg, Russia
- *Sixth NAIC/NRAO School on Single Dish Radio Astronomy*, 10 – 16 July 2011, Green Bank, West Virginia, USA
- *Four Decades of Research on Massive Stars: A Scientific Meeting in the Honour of Anthony F.J. Moffat*, 12 – 14 July 2011, Lanaudière, Québec, Canada
- *Galaxy Formation*, 18 – 22 July 2011, Durham, UK
- *IAU Symposium No.283: Planetary Nebulae: An Eye to the Future* 25 – 29 July 2011, Tenerife, Spain
- *The 11th Asian Pacific Regional IAU Meeting*, 26 – 29 July 2011, Chiang Mai, Thailand
- *32nd. International Cosmic Ray Conference*, 11 – 18 August 2011, Beijing, China
- *Magnetic Fields in the Universe: from Laboratory and Stars to Primordial Structures III*, 21 – 27 August 2011, Tatra Mountains, Poland
- *Jan65: Magnetic Fields and the Cosmos*, 24 – 26 August 2011, Nijmegen, The Netherlands
- *IAU Symposium 284: The Spectral Energy Distribution of Galaxies (SED2011)*, 5 – 9 September 2011, Preston, UK
- *The Starburst-AGN Connection under the Multiwavelength Limelight* 14 – 16 September 2011, Villafranca del Castillo, Spain
- *FIR2011: Star Formation and Feedback in Galaxies as Revealed by Far Infrared and Submillimeter Wavelengths*, 14 – 16 September 2011, London, UK
- *6th IRAM 30m Summer School, Star formation - Near and Far*, 23 – 30 September 2011, Sierra Nevada, Spain
- *Through the Infrared Looking Glass: A Dusty View of Galaxy and AGN Evolution*, 2 – 5 October 2011, Pasadena, California, USA
- *Formation and Early Evolution of Very Low Mass Stars and Brown Dwarfs*, 11 – 14 October 2011, Garching, Germany
- *A Workshop on the Emerging, Multi-wavelength View of the Galactic Centre Environment*, 17 – 20 October 2011, Heidelberg, Germany
- *Midwest Astrochemistry Meeting 2011*, 21 – 22 October 2011, Urbana, Illinois, USA
- *Galaxy Mergers in an Evolving Universe*, 23 – 28 October 2011, Hualien, Taiwan
- *Science with Parkes at 50 years Young*, 31 October – 4 November 2011, Parkes Telescope, NSW, Australia
- *High Energy Astroparticle Physics 2011 - Gamma-Ray Universe: Fermi to CTA*, 13 – 15 November 2011, Tsukuba, Japan

- *6th Korean Astrophysics Workshop: Fundamental Processes of Astrophysical Turbulence*, 16 – 19 November 2011, Pohang, Korea
- *IAU Symposium 287: Cosmic Masers: From OH to H₀*, 29 January – 3 February 2012, Stellenbosch, South Africa
- *The Second AKARI Conference, Legacy of AKARI: A Panoramic View of the Dusty Universe*, 27 – 29 February 2012, Jeju island, Korea
- *Circumstellar Dynamics at High Resolution*, 27 February – 2 March 2012, Foz do Iguacu, Brazil
- *IAU Symposium 279 - Death of Massive Stars: Supernovae & Gamma-Ray Bursts*, 12 – 16 March 2012, Nikko, Japan
- *From Atoms to Pebbles: Herschel's View of Star and Planet Formation*, 20 – 23 March 2012, Grenoble, France
- *Cosmic-ray Induced Phenomenology in Star-Formation Environments (2nd Workshop of the Sant Cugat Forum on Astrophysics)*, 16 – 19 April 2012, Sant Cugat, Barcelona, Spain
- *RTS 2012- Resolving The Sky - Radio Interferometry: Past, Present and Future*, 18 – 20 April 2012, Manchester, UK
- *First Stars IV - From Hayashi to the Future*, 21 – 25 May 2012, Kyoto, Japan
- *The Physics of Feedback Processes and their Role in Galaxy Evolution*, 10 June – 1 July 2012, Aspen, Colorado, USA
- *The Labyrinth of Star Formation*, 18 – 22 June 2012, Crete, Greece
- *Ultraviolet Astronomy: HST and Beyond*, 18 – 21 June 2012, Kauai, Hawaii, USA
- *7th International Conference on Numerical Modeling of Space Plasma Flows - ASTRONUM-2012*, 24 – 29 June 2012, Big Island, Hawaii, USA
- *Centenary Symposium 2012: Discovery of Cosmic Rays*, 26 – 28 June 2012, Denver, Colorado, USA
- *PoS 2012 The Early Phase of Star Formation - Assembling Pieces of the Missing Paradigm*, 1 – 6 July 2012, Tegernsee, Germany

The Division is supporting a number of Symposia and Special Sessions and is the coordinating Division for Special Sessions 12 and 16 at the IAU XXVIII General Assembly in Beijing, August 2012.

- *IAU Special Session 3: Galaxy Evolution Through Secular Processes*, 12 – 16 August 2012, Beijing, China
- *IAU Symposium 288: Astrophysics from Antarctica*, 20 – 24 August 2012, Beijing, China
- *IAU Symposium 292: Molecular Gas, Dust, and Star Formation in Galaxies*, 20 – 24 August 2012, Beijing, China
- *IAU Special Session 4: New era for studying interstellar and intergalactic magnetic fields*, 20 – 23 August 2012, Beijing, China
- *IAU Special Session 8: Calibration of star-formation rate measurements across the electromagnetic spectrum*, 27 – 30 August 2012, Beijing, China
- *IAU Special Session 12: Modern views of the interstellar medium* 27 – 31 August 2012, Beijing, China
- *IAU Special Session 16: Unexplained spectral phenomena in the interstellar medium*, 27 – 28 2012, Beijing, China

4. Proceedings and monographs

4.1. Conference proceedings

- *The Magellanic System: Stars, Gas, and Galaxies*. Proc. IAU Symposium No. 256, Eds. J. Th. van Loon & J. M. Oliveira (Cambridge: CUP), 2009
- *Cosmic Magnetic Fields: From Planets, to Stars and Galaxies*. Proc. IAU Symposium No. 259, Eds. K. G. Strassmeier, A. G. Kosovichev & J. E. Beckman (Cambridge: CUP), 2009
- *AKARI, a Light to Illuminate the Misty Universe*. Eds. T. Onaka, G. J. White, T. Nakagawa, & I. Yamamura (San Francisco: Astronomical Society of the Pacific Conference Series, vol 418), 2009
- *The Dynamic Interstellar Medium: A Celebration of the Canadian Galactic Plane Survey*. Eds. R. Kothes, T. L. Landecker, & A. G. Willis (San Francisco: Astronomical Society of the Pacific Conference Series, vol 438), 2010
- *Asymmetric Planetary Nebulae 5*. Eds. A. A. Zijlstra, F. Lykou, I. McDonald, & E. Lagadec (Jodrell Bank Centre for Astrophysics), 2011
- *Computational Star Formation*. Proc. IAU Symposium No. 270, Eds. J. Alves, B. Elmegreen, & V. Trimble (Cambridge: CUP), 2011
- *Active OB stars: structure, evolution, mass loss, and critical limits*. Proc. IAU Symposium No. 272, Eds. C. Neiner, G. Wade, G. Meynet, & G. Peters (Cambridge: CUP), 2011
- *The multi-wavelength view of hot, massive stars*. Eds. G. Rauw, M. De Becker, Y. Nazé, J.-M. Vreux, P. Williams (Liège: Société Royale des Sciences de Liège, Bulletin, vol. 80), 2011

4.2. Research monographs

- *Physics of the Interstellar and Intergalactic Medium*. Bruce T. Draine (Princeton: Princeton University Press), 2011

5. Review articles

Recent invited reviews on interstellar matter published in the Annual Reviews of Astronomy and Astrophysics or the Publications of the Astronomical Society of the Pacific have included:

- Kalberla, P. M. W., & Kerp, J. 2009, *ARA&A*, 47, 27, *The HI Distribution of the Milky Way*
- Zweibel, E. G., & Yamada, M. 2009, *ARA&A*, 47, 291, *Magnetic Reconnection in Astrophysical and Laboratory Plasmas*
- Herbst, E., & van Dishoeck, E. F. 2009, *ARA&A*, 47, 427, *Complex Organic Interstellar Molecules*
- Churchwell, E., et al. 2009, *PASP*, 121, 213, *The Spitzer/GLIMPSE Surveys: A New View of the Milky Way*
- De Marco, O. 2009, *PASP*, 121, 316, *The Origin and Shaping of Planetary Nebulae: Putting the Binary Hypothesis to the Test*
- Calzetti, D., & Kennicutt, R. C. 2009, *PASP*, 121, 937, *The New Frontier: Galactic-Scale Star Formation*
- Henning, T. 2010, *ARA&A*, 48, 21, *Cosmic Silicates*
- Adams, F. C. 2010, *ARA&A*, 48, 47, *The Birth Environment of the Solar System*
- Mann, I. 2010, *ARA&A*, 48, 173, *Interstellar Dust in the Solar System*

- Dullemond, C. P., & Monnier, J. D. 2010, *ARA&A*, 48, 205, *The Inner Regions of Protoplanetary Disks*
- Bastian, N., Covey, K. R., Meyer, M. R. 2010, *ARA&A*, 48, 339, *A Universal Stellar Initial Mass Function? A Critical Look at Variations*
- Fukui, Y., & Kawamura, A. 2010, *ARA&A*, 48, 547, *Molecular Clouds in Nearby Galaxies*
- Smith, I. W. M. 2011, *ARA&A*, 49, 29, *Laboratory Astrochemistry: Gas-Phase Processes*
- Williams, J. P. & Cieza, L. A. 2011, *ARA&A*, 49, 67, *Protoplanetary Disks and Their Evolution*
- Kotera, K., & Olinto, A. V. 2011, *ARA&A*, 49, 119, *The Astrophysics of Ultrahigh-Energy Cosmic Rays*
- Armitage, P. J. 2011, *ARA&A*, 49, 195, *Dynamics of Protoplanetary Disks*
- Frisch, P. C., Redfield, S., & Slavin, J. D. 2011, *ARA&A*, 49, 237, *The Interstellar Medium Surrounding the Sun*

You-Hua Chu
president of the Division