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A. (APPENDIX) REPORT OF WORK DONE IN U.S.S.R. ON SOLAR RADIO-EMISSION

(prepared by V. V. Bazykin)

In 1960–62 the solar radio-emission was studied by the following institutions: Main Astronomical Observatory, Academy of Sciences of U.S.S.R., Lebedev Physical Institute, Academy of Sciences of U.S.S.R., Institute of Terrestrial Magnetism, Ionosphere and Propagation of Radiowaves, Academy of Sciences of U.S.S.R., Astrophysical Laboratory, Academy of Sciences of Latvian S.S.R., Siberian Institute of Terrestrial Magnetism, Ionosphere and

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Propagation of Radiowaves, Academy of Sciences, U.S.S.R., Radio-astronomical Laboratory of the Institute of Radio Physics and Electronics, Academy of Sciences of Ukrainian S.S.R., Radio Physics Research Institute and Leningrad University.

Occultations of the Crab Nebula by the solar corona on wavelength 6·3 cm were observed, and it was found that the Sun general magnetic field does not exceed $8 \cdot 10^{-3}$ gauss at a distance of 5 to 6 Sun radii (**1**). By scanning with a small pencil beam, an attempt was made to measure the ellipticity of the Sun radio disk on centimeter wavelengths (**2**).

After new series of observations using the large Pulkovo radio telescope of which the east-west resolution is about one minute of arc on 3 cm and three minutes on 8·7 cm, it was established that the angular dimensions of the sources in the 2 to 10 cm band do not exceed the dimensions of the connected groups of spots and in a number of cases are near one minute of arc. On 8·7 cm the brightness temperature reaches 2 to 3 10^6 degrees. Observations in various bearings allowed to determine both co-ordinates of the sources with respect to the spots. Besides the displacement of the source relative to the spot which depends on the height of the source over the photosphere, the source appears to be displaced towards the equator, the value of the displacement reaching sometimes one minute of arc. The lifetime of the local source on 8·7 cm was found to be much longer than that on 3 cm and can exceed the lifetime of the group of spots by a full month.

The observations of the solar eclipse on 1961, February 15, in the 2 to 21 cm range showed that dimensions of the emitting zone over a spot depend on the wavelength. From 9 to 21 cm the linear dimensions become about three times larger. The source spectrum has its maximum on 6 to 8 cm. The nature of the spectrum reveals strong influence of the magnetic field on the emission process. The flux spectrum from the bright flocculi which were in the eclipse zone in the disc centre does not materially differ from the decelerating thermal radiation spectrum of an optically thin layer (**3, 7, 10, 11, 12, 13, 14, 15**). In some cases, dark areas related to the solar prominences were observed on 3 and 21 cm (**4, 9, 10**).

The observations of the solar eclipse on 1962, July 31, allowed to determine accurately the solar radio diameter on 3·2 and 4·5 cm. A marked increase of diameter compared to measurements of 1958 was noticed (**29**).

Using a three-component spectrograph the inclination and the residual intensity at the frequency of hydrogen excitation (3·04 cm) were measured in the 3 cm band for more than 100 radio bursts; 18% of them show a residual intensity that noticeably differs from 1 and is within 0·9 to 1·1. The most typical is expressed as $\nu^{-0 \cdot 75}$, where ν is the frequency. In individual cases the power value reaches as much as -8 to -3. Near the maximum of the flux, characteristic changes have been observed (**16, 17, 18**).

The observations included detailed analysis of the burst polarization on 2·2 and 4·9 cm. In most of the cases the polarization was practically circular while the degree of polarization is about 12% of excess of ordinary wave. A decrease in the polarization degree was often observed near the maximum of intensity. A thermal model, which explains the variations of flux and the polarization degree by expansion of a hot condensation of matter in the corona, was considered. After processing the data of observations made on 1961, July 19, the variations in temperature, density and dimensions of the emitting zone were determined. The measured temperature gradient brings about the change in the polarization sign to a longer wave (**19**).

A statistical method of determining the magnetic field by measuring the ellipticity of the burst polarization has been proposed. The application of this method to the observations made by Akabane (Japan) on 3·15 cm gives average field of about 500 gauss (**20**).

The radio bursts were studied in the 10 to 26 Mc/s band. The structure of the observed bursts was a complicated one, each one consisting in a large number of comparatively narrow-pole outbursts which continuously changed their shape and position on each frequency (**21**).

From the observations made during the total solar eclipse on 1961, February 15, the Sun radio dimensions were determined in the range of 20 cm to 4 m (41′·5 on 1·45 m, 46′·5 on 2·5 m, 51′.5 on 4 m). The values of residual intensity at the totality were: 23·8% on 22 cm, 24% on 83 cm, 34% on 1·45 m, 52% on 2·6 m and 66% on 4 m. The shape of the radio brightness distribution over the Sun disk is similar for the whole range. Co-ordinates, dimensions and brightness temperatures of Sun 'radio spots' for the eclipse day were also determined (this gives $2 \cdot 10^5$ °K for 22 cm and $4 \cdot 10^7$ °K for 83 cm) (**22, 23**).

In the external corona, plasmoids (at distances of $4\,R_0$) and plasma inhomogeneities which cause variations of radio emission in the decimetre range, were found. The possibility of plasma cloud movements as satellites of the Sun was considered.

Possible cause of distortion in the regular structure of the solar super-corona magnetic fields were also considered (**24, 25**).

The influence of the super-corona on radio emissions of several solar active zones was calculated at the case of radial distribution of irregularities, taking into account the limited distance from the emission source to diffusing areas of the super-corona. Among other data obtained were: the values of attenuation factor due to this limited distance from the source to the diffusing zones; the estimates for the attenuation of the diffusion effect depending on the source position (3 to 10^2 times); the observed angular dimensions of the solar active zones on 3·5, 5·8 and 12 m (13′·37 and 155′ respectively) (**26**).

On 8 m, series of studies of distribution of Sun radio-brightness and radio-emission bursts were carried out with the use of the PT-22 radio telescope (Physical Institute, Academy of Sciences). Two-dimensional Sun 'radio images' were obtained, and it was shown that the enhanced radio emission comes from areas which are usually located over the flocculae fields. The angular dimensions of the active zones were determined (1′–2′, sometimes 4′–5′) and also the increase in the brightness temperature over the quiet Sun level ($2{\cdot}5 - 6 \cdot 10^3$ °K). The 'radio bright spots' have been identified with zones optically active on the Sun disk and dynamic changes of 10 zones were observed. The comparison of the 'radio images' on 8 m and 3·2 cm showed that the discrete source are of thermal nature, and are optically thin on millimetric and the centimetric wavelengths (**27**).

The radio bursts which begin at the same time as chromospheric flares have been localized, their angular dimensions and maximum brightness temperatures (10^4–10^6 °K) estimated (**40**).

The spectrum of the Sun radio-emission was studied on 1·8 mm, and from 3 to 7 millimeter and theoretical research of the Sun radio-emission mechanism continued.

On 8 to 9 Mc/s and 25·13 Mc/s simultaneous observations of sporadic Sun radiation were carried out (**30**).

Study of the radio-emission mechanism of the sources over groups of Sun spots is beginning. It has been established that the sources have strong magnetic fields exceeding 1000 oersteds which can hardly be explained by decelerating radiation only.

Theoretical Research on Solar Radio-emission

The propagation of electro-magnetic waves in the solar corona were studied.

Among the problems considered were:

(1) characteristic interaction of waves in the zone of quasi-transversal magnetic field and its relation to the peculiarities of the microwave bursts polarization (**31**);

(2) transversal transformation of longitudinal waves in conditions of non-homogeneous coronal plasma and its role in the solution of problems of radio-emission from the corona (**32**);

(3) conditions for amplification and instability of electromagnetic waves at anisotropy of temperatures in plasma (**33, 36**).

The study of Sun sporadic radio-emission mechanism was continued (non-coherent radio-

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emission mechanism for the metric band (**37**) and synchrotron mechanism for generating the slowly varying component (**38**, **39**)). It was shown in particular, that combined action of Bremsstrahlung and synchrotron radiation provides an explanation for basic characteristics of this component.

The possibility of determining the intensity of magnetic field in the external solar corona by observation of the polarization of the occulted discrete sources, was studied.

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