C. (APPENDIX) REPORT OF WORK DONE IN U.S.S.R. ABOUT GALACTIC AND EXTRAGALACTIC RADIO-EMISSION

(prepared by V. V. Bazykin)

Radio-astronomical investigations of Galaxy and Metagalaxy were carried out by the Institute of Radio Physics and Electronics, Academy of Sciences of Armenian SSR; Institute of Radio Physics and Electronics, Academy of Sciences of Ukrainian SSR; Radio Physics Research Institute, Ministry of Higher and Secondary Special Education; Sternberg Astronomical Institute; Lebedev Physical Institute, Academy of Sciences of U.S.S.R. and Main Astronomical Observatory, Academy of Sciences U.S.S.R. The purpose of the investigation was to measure the absolute fluxes of sources Cassiopeia-A, Virgo-A, Cygnus-A and Taurus-A, in the frequency range 12 to 40 Mc/s. It was shown that below 20 to 25 Mc/s the intensity of all the sources (with exception of Taurus-A) decreases (**1–5**).

With the use of the artificial Moon method fluxes from discrete source Cassiopeia-A on 3·2 and 9·8 cm were calibrated. The values obtained are respectively:
$(5{\cdot}2 \pm 0{\cdot}15) \times 10^{-24}$ W m^{-2} hz^{-1}, $(14{\cdot}6 \pm 0{\cdot}5) \times 10^{-24}$ W m^{-2} hz^{-1} (**6**).

The spectral index measured $\alpha = -0{\cdot}87$ which differs from the one obtained before for the entire frequency range ($\alpha = -0{\cdot}8$).

Taurus and Orion nebulae fluxes were calibrated on $\lambda = 3{\cdot}2$ cm, the fluxes measured are $(5{\cdot}6 \pm 0{\cdot}3) \times 10^{-24}$ W m^{-2} hz^{-1} and $(4{\cdot}5 \pm 0{\cdot}3) \times 10^{-24}$ W m^{-2} hz^{-1} for the central part of Orion nebula, diameter 6′ (**7**).

On wavelength 3·2 and 10·25 cm, measurements were done again to check the data obtained in 1961 for the centimetre wavelengths during the calibration of Cassiopeia-A flux, and to draw out the effect of the diameter on the precision of flux calibration using the artificial Moon method. The fluxes measured are:
$(5{\cdot}14 \pm 0{\cdot}30) \times 10^{-24}$ W m^{-2}hz^{-1} and $(15{\cdot}26 \pm 0{\cdot}30) \times 10^{-24}$ W m^{-2}hz^{-1} respectively, which support the spectral index of Cassiopeia-A $\alpha = -0{\cdot}87$ obtained before.

Cygnus-A flux, calibrated on $\lambda = 10{\cdot}26$ cm, is $(7{\cdot}5 \pm 0{\cdot}5) \times 10^{-24}$ W m^{-2}hz^{-1} (**9**). The spectral indexes calculated with the use of these data are: $\alpha = -0{\cdot}81$ for Cassiopeia-A, $\alpha = -0{\cdot}24$ for Taurus-A and $\alpha = -0{\cdot}85$ for Cygnus-A.

Several diffusion nebulae were observed and the data obtained were theoretically interpreted (**11, 12**).

Paper (**13**) contains theoretical grounds for a secular variation in radio emission for young envelopes of super-novae; the paper shows, in particular, that a good accuracy in observation would allow the detection of the effect of this variation in the flux of Cassiopeia-A. Some years later this effect was actually observed by Soviet, American and British scientists.

Papers (**14, 15**), based on the studies of Cygnus-A radio galaxy spectrum, provide grounds for the conclusion that the age of this source is $(0{\cdot}1 \text{ to } 1) \times 10^6$ years and that the sources of radio emission are moving off from their native galaxy near the light velocity.

Papers (**16, 17**) show dependence of spectral index of radio galaxies and of super-nova envelopes on their absolute radio magnitudes and contain a possible theoretical interpretation of this effect.

Papers (**18–22**) are devoted to the theory of discrete galactic and extragalactic sources of synchrotron emission.

Papers (**22–24**) contain information on the observations of the Galaxy periphery in the 21-cm line. A considerable thickening of the Galaxy gas disk has been detected in the periphery. A model of the gas disk for the whole Galaxy has been constructed, the curvature and thickening

of the gas disk resulting from its interaction with the intergalactic medium were theoretically interpreted.

Paper (**25**) contains information on observations in the 21-cm line of association Tau T2.

Paper (**26**) describes an attempt to detect emission in the 21-cm line from two Galaxy clusters; the upper estimate of the hydrogen mass in the clusters has been made.

Paper (**18**) is devoted to a model of neutral hydrogen distribution within the Galaxy with a clearly expressed spiral structure; the model was constructed on the basis of introduction of systematic K-effect in the Galaxy rotation laws and on the observations in the 21-cm line.

The boundary limit of the longitudinal component of the regular magnetic field in the plane of Galaxy in the direction of the anticentre was assessed to be $H = 0{\cdot}3 \times 10^{-7}$ gauss (**28**).

On the basis of observations on the 21-cm wavelength the spatial distribution of neutral hydrogen in the central part of the Cygnus constellation has been obtained within the limits in α: $20^h\ 04^m$-$20^h\ 44^m$ and in δ: $38° - 46°$.

It has been found that the Cygnus-X radio source located there lies inside our nearest galactic spiral arm and comprises at least two parts located at different distances (**29-31**).

Co-ordinates, angular dimensions, radio flux density of 80 discrete sources have been measured on 10 cm. The measurements allowed to obtain independent data on electron density, mass and dimensions of the diffusion nebulae (**32, 33**).

Polarization of the Crab nebula radio-emission has been measured at 20 cm: the amount of polarization is $\rho = 0{\cdot}5\%$ in position angle $\psi = 82°$ (**28**).

Angular dimensions and radio-emission flux densities of discrete sources Cassiopeia-A, Cygnus-A, Omega and Orion on 3·2 cm have been measured.

Theoretical studies of Galaxy and Metagalaxy radio-emission were carried out in conjunction with the problem of mutual concentration of cosmic rays, and in particular, of their electron component in the Metagalaxy space. As results from the analysis, the conclusion that the cosmic rays concentration in the Metagalaxy space is considerably lower than in Galaxy appears now as the most probable one (**47**).

The problem of general Galaxy radio-emission spectrum was considered assuming that the emitting electrons are due to nuclear collisions in the interstellar medium. The energy spectrum of the secondary electrons and positrons, the radio-emission spectrum as observed from the Earth with due allowance for synchrotron losses and Compton losses, as well as the diffusion, are calculated. It has been shown that one may account for a considerable reduction of radio-emission spectral index at low frequencies and for the observed intensity.

The calculated and observed data are compared and are in good agreement. However, the final conclusion as to the nature of radio-emitting electrons in Galaxy will become possible only after more precise observations (**48**).

The investigations of the central parts of the galaxy was continued on wavelengths 3·2, 8·7, 9·4, 21 and 33 cm (**34, 35, 36, 37, 38, 39, 40**). On wavelength 21 cm Sagittarius-A source components were separated. The central bright source is not purely thermal, while the spectra of parts of the Drake ring are different (**39, 40, 41**). An attempt to interpret the phenomena in the central part of Galaxy was undertaken (**34**).

Radio brightness distribution of Orion nebula (NGC1976), Omega (NGC6618), NGC6523, NGC6514 was obtained. Detailed comparisons to the optical data were done and models of Orion and Omega sources constructed (**42, 43**). The distribution of radio brightness in Crab nebula obtained on wavelength 3·2 and 6·4 cm reveals strict boundaries in the radio-emission source which coincide with the filamentary shell of the nebula. Distribution of radio brightness on wavelength 21 cm has been obtained (**45**) and distribution of Crab nebula polarized radio-

emission on wavelengths 3·2 and 6·4 cm studied. It was found that the polarized radio-emission zone is much smaller than the non-polarized one while the polarization percentage on 3·2 cm is close to the optical one (**44, 46**). Right ascensions of radio sources Cygnus-A, Sagittarius-A (the central part), Omega, Orion, Crab nebula were measured with an accuracy of ± 1′ and their integrated fluxes were determined on wavelengths 3·2 and 21 cm (**38**).

21-cm line absorption on source Sagittarius-A was studied on two frequencies of line profile ($V = 0$ and $V = -53$ km/sec). The neutral hydrogen from the 3 kpc arm does not absorb the emission of the south-western part of Drake ring (**39, 40, 41**).

Distribution of brightness for Cygnus-A was obtained on wavelength 3·2 cm. The distribution reveals two sources with dimensions 25″ and 40″ and relative intensity of 1:1·2. The distance between them is 102″; the emission between the sources is practically absent. A model of the source based on the comparison with the observations by other observers is proposed (**38**).

It has been found that over 80 per cent of emission on wavelength 8·7 cm in radio galaxy Virgo-A originates in a point source whose diameter is less than 1′. The co-ordinates carefully measured reveal a displacement of the source $3^s \pm 1^s$ in the direction of escape from the centre of Galaxy (**35**). Distribution of radio brightness on wavelength 21 cm was obtained (**45**). Observations of radio sources Sagittarius-A and Omega (NGC6618) on wavelength 32·5 cm have been completed. It was shown that the Sagittarius-A contains three components. The spectrum of component 1 is either a thermal one or a combination of a thermal spectrum with a non-thermal one. Component 2 is symmetrical relative to component 1 and is connected with the galactic nucleus. Component 3 is identified with gas nebulae located between them and the galactic centre (**49**).

Identification of radio sources with galaxies in clusters was carried out. On the basis of the identification, a dependence of the binary galaxy radio emission power on the relative distance between the components of the galaxy was assessed (**50**).

In co-operation with the British astronomers the neutral hydrogen was studied on wavelength 21 cm in five galactic clusters: Pleiades, NGC1502, Trapezium, Orion, NGC2244 and NGC6910 (**51**).

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D. RADIOASTRONOMICAL INSTRUMENTS

(prepared by R. N. Bracewell)

New radio telescopes in several categories have come into use, new receivers have been developed, and techniques of data processing have developed further.

Reflectors

A large altazimuth reflector of 64-m aperture has come into operation in Australia (**1**). In the U.S.A., a meridian mounted reflector of 91 m aperture (**2**), and the fixed parabolic cylinder of 121 × 183 m aperture (**3**) have come into use, and the 305 m fixed spherical reflector has undergone preliminary tests (**4**). Portions of the fixed-tiltable reflectors of Ohio (**5, 6**) and Nançay (**7**) have been used for observations. A fixed spherical reflector 24 m in diameter for operation at 21 cm has been constructed at Mitaka. Construction has begun on a 46 m steerable reflector for 3 cm operation at Algonquin Park.

Interferometers

An interferometer comprising two 27-m reflectors has been constructed in California (**8**).