F. MAGNETIC FIELDS, PULSARS, X-RAY AND GAMMA-RAY EMISSION

1. Magnetic Fields

During the triennium under review many papers reported on studies of the structure of the galactic magnetic field. Andreasyan used rotation measures (RM) of large samples of extra-galactic radio sources and pulsars (29.156.001) or radio sources (32.156.002), and Inoue and Tabara (31.156.011) used in addition optical polarization of stars to investigate the direction of the large-scale regular magnetic field. Thomson and Nelson analyse the RMs of 459 extragalactic sources (32.161.001) to determine the best fit parameters for a galactic magnetic-field model, and find agreement with their earlier work using pulsars (27.156.009). Similarly, Sofue and Fujimoto (33.155.011) show that the characteristic features of the RM distribution on the sky are well reproduced by a model in which the magnetic field is in a bisymmetric, two-armed logarithmic spiral configuration. Finally, Welter, Perry and Kronberg (37.159.096) present a statistical analysis of the (Galaxy-corrected) residual rotation measure (RRM) of 116 QSOs.

In the triennium, large-scale magnetic field structures in nearby galaxies were discussed, e.g., M31 by Beck (31.158.085), and NGC 6946 and NGC 253 by Klein et al. (31.158.111, 34.157.071). The fields in these nearby galaxies are found to be substantially higher than had been previously thought to exist. Ordered fields of up to 10 μG, over kiloparsecs appear frequently.

Rumaikin and Shukurov (30.156.007, 31.156.017) evaluate again the large-scale and small-scale galactic magnetic fields, generated and maintained due to the turbulent dynamo-action. Vallee and colleagues (32.156.006, 34.131.110, 37.131.179) discuss the discovered "magnetic bubbles" of sizes ranging from about 0.1 to 1 kpc; in analogy to the two known magnetic bubbles, loop I and loop II, they propose the areas of the Gum Nebula and the Monogem X-ray ring (30.142.013) to be new 'magnetic bubbles' near the Sun. A quantitative estimate of the apparent effects of the four large interstellar magnetic bubbles near the Sun on the RM data of distant radio sources has recently appeared (Vallee, 1984): The mean RM contribution is ∿ 90 rad m^{-2}. Finally, the large-scale structure of the magnetic field in the Perseus spiral arm is derived by Vallee (34.155.005).

Phillips et al. (29.156.008, 30.156.010) interpret the new all-sky radio continuum map at 408 MHz (Haslam et al., 30.141.017) to derive a large-scale emissivity distribution. Sarkar (32.156.015) evaluates the possibility that the galactic synchrotron radio background originates in old supernova remnants. Brown (33.155.049) and Kanbach (34.155.020) discuss in detail the galactic distribution of cosmic-ray electrons and magnetic fields, reflected in the galactic non-thermal radio background. Brown stresses the intimate relation between interpretations of the radio and gamma-ray backgrounds and the distribution of the thermal material in the Galaxy. Earlier, Haslam et al. (29.157.001) showed the large-scale similarity of the gamma-ray and synchrotron distributions in the galactic plane. Spoelstra (37.155.086) discusses the polarization characteristics of Galactic radio emission at frequencies 408, 465, 610, 820 and 1411 MHz.

2. Pulsars

The proceesings of IAU Symposium No. 95 on "Pulsars" (29.012.037) provide a complete review of the topic up to 1981. Three contributions are concerned with the galactic distribution of pulsars (29.141.593, 29.141.594, 29.141.595) and are of special interest for this report. Lyne (29.141.593, 32.141.535), Guseinov, Kasumov and Yusifov (29.141.594, 31.141.514, 31.141.526) and Harding (29.141.595) arrive at different parameters on the details of this distribution, but agree on the large-

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scale appearance, such as a wide (∿ 8 kpc) distribution above and below the galactic plane, a ring-shaped (or spiral-arm-like) structure reaching a maximum at ∿ 5 kpc and a pulsar birth rate of one pulsar every 20 to 50 years. Morini (30.141.546) performed Monte-Carlo simulations to derive the galactic distribution.

Vivekanand and Narayan (30.141.555) and Huang, Huang and Peng (33.141.009) study the P-$\dot{P}$ relation. The latter authors propose under a new pulsar spindown configuration ($\dot{P} \propto P^2$) that there might be two types of pulsars which could be correlated with two types of supernovae. Anderson and Lyne (33.141.085) study a sample of 26 pulsars and point out that their velocities are closely correlated with either the magnetic dipole moments, or their moments of inertia. They find no relation between the directions of the proper motions and the pulsar spin axes.

3. Diffuse Galactic Gamma Radiation

In the context of the XVIII general assembly of the IAU, a meeting was organised on "Galactic Astrophysics and Gamma-Ray Astronomy". The readers are referred to the proceedings (34.012.016) for a complete review of the field of gamma-ray astronomy up to the end of 1982. Most new results are derived from the COS-B data base for energies $\gtrsim$ 70 MeV (e.g. 31.157.002). At lower gamma-ray energies, new results have been derived from balloon measurments by Graser and Schönfelder (32.157.013), Sacher and Schönfelder (34.143.021), and Bertsch and Kniffen (34.143.003).

For this report, the most important progress made during this triennium concerned correlation studies between the gamma-ray distributions and the distributions of gas tracers; gamma radiation being a tracer of the product of the cosmic-ray density and the total interstellar gas density, integrated along the line of sight. The contribution from Inverse-Compton gamma rays (e.g. 30.157.015, and Bloemen, 1984) and point sources (e.g. pulsars, 31.142.528, 29.157.002, 30.157.001, 34.141.076) has been ignored in most works.

Gamma rays and the local interstellar medium. The SAS-2 detection of the structure of Gould's Belt in gamma rays has been confirmed in detail using COS-B data (31.157.002). A second local disc-shaped structure similar to Gould's Belt, but independent of it (Dolidze, 27.155.037, 28.155.046), has been shown to be visible in the COS-B data by Bignami (30.157.012) and Bignami et al. (32.012.070). Lebrun et al. (31.142.507) and Strong et al. (32.131.267) study the relation between galaxy counts and gamma rays measured by COS-B for $10^{\circ} < |b| < 20^{\circ}$. They show that a close bidimensional correlation exists between gamma-ray intensities and total-gas column densities as estimated from galaxy counts. Analyses of this type applied to SAS-2 data by Lebrun and Paul (1979, 33.131.050) and Strong and Wolfendale (30.157.011) reached similar conclusions. Strong et al. (32.131.267) and Bloemen (33.155.035) present for this latitude range a map of the distribution of molecular-hydrogen column density, $N(H_2)$, based on the excess gamma-ray flux over that predicted from atomic hydrogen, HI, alone. The map includes both hemispheres, and establishes the H_2 angular distribution on scales $< 10^{\circ}$. The Orion (28.131.145) and ρ-Ophiuchus (34.143.013, 34.155.031) cloud complexes have been resolved in gamma rays. Bloemen et al. (1984) find for the large complex of interstellar clouds in Orion and Monoceros a good correlation between the gamma-ray emission and the total-gas distribution, using a Columbia CO survey to trace the H_2. This correlation is used to calibrate the ratio between H_2 and the integrated CO line intensity: $N(H_2)/W_{CO} = (2.6 \pm 1.1)\ 10^{20}$ molecules $cm^{-2}\ K^{-1}\ km^{-1} s$.

Gamma rays from atomic and molecular gas in the galactic plane. Bloemen, Blitz and Hermsen (33.155.086, 37.155.065) present a method by which the radial distribution of galactic high-energy gamma-rays (70 MeV-5 GeV) can be determined. In a follow-up paper (Bloemen et al., 37.155.072) the radial distribution of the gamma-ray emissivity in the outer Milky Way is derived, using HI column-density maps in various galacto-centric distance ranges in the outer Galaxy in combination with COS-B gamma-ray data. Their results are interpreted as a steep gradient in the cosmic-ray electron density and a near constancy of the nuclear component out to large ($\sim$ 20 kpc) galacto-centric distances. The variation of the electron component, with effective pathlength $\sim$ 4 kpc, is shown to be consistent with low-frequency radio continuum observations (e.g. 27.156.001, 29.156.008). In this triennium, earlier studies on cosmic-ray gradients are presented by Li Ti Pei and Wolfendale (30.155.011) and Issa et al. (30.155.012). Arnaud et al. (32.142.523) and Lebrun et al. (34.131.199) compare the COS-B gamma-ray survey with a Columbia CO survey and Berkeley HI surveys for the inner galaxy. Lebrun et al. found that a simple model in which uniformly distributed cosmic rays interact with the interstellar gas, as traced by HI and CO, can account for almost all the gamma-rays (E > 300 MeV) observed from the first quadrant. They calibrated the ratio $N(H_2)/W_{CO}$ = (1-3) 10^{20} molecules cm^{-1} K^{-1} km^{-1} s, fully consistent with the value derived from Orion-Monoceros data. Korchagin, Korchagin and Suchkov (33.155.100) and Fichtel and Kniffen (37.155.056) model the interstellar gas distribution, using recent considerations of this distribution from radio and mm data, to predict the galactic gamma-ray distribution.

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VII. Galactic Environment

The galactic environment comprises of five distinct populations: hot gaseous corona, high-velocity clouds of neutral hydrogen (HVCs), dwarf companion galaxies and extended distant globular clusters, and an invisible massive corona of still unknown origin.

The presence of the hot gaseous corona has been demonstrated principally by IUE observations of distant stars, galaxies and quasars. Absorption features of highly ionized atoms (CIV, CVI, SiIV) have been discovered. Redshifts indicated that absorption originated partly in the Galactic disk and in the Magellanic Clouds, but partly in the gaseous corona (30.131.027, 30.158.161, 31.131.058, 32.131.082, 32.155.060; reviews are given in 32.158.075, 32.155.028, 33.131.022, 33.131.138).

Mirabel and Morras (37.155.063) have performed a new sensitive survey of neutral hydrogen in the velocity interval -1000 to +1000 km/s; 120 clouds have been discovered. In the galactic anticenter region, all clouds have negative galacto-centric velocity; in the galactic center region, 15 % of the clouds have positive velocities. Cohen (30.131.006) discovered a 25^{o} long, high-velocity stream colliding with gas in the galactic disk. Detailed studies of individual HVCs have been continued (30.131.112, 31.159.005, 32.131.089, 32.131.264, 33.131.017, 33.131.173). The current observational status of HVCs and the Magellanic Stream is reviewed by Mirabel (30.159.017, 32.131.150) and by Mathewson and Ford (37.156.032).

The dominance of negative galactocentric velocities of HVCs is explained in the galactic fountain model (Shapiro and Field, 17.131.112). Cold and dense gas of the galactic disk will be locally heated by supernova explosions up to a tempera-

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ture 10^6 K. The heated gas flows away from the galactic plane, where it cools and condenses slowly. The cooled clouds fall back toward the disk. Dynamics of the galactic fountain has been studied in detail (29.131.110, 30.155.052, 30.158.146, 31.131.012, 31.131.029, 32.131.261). HVCs can also be tidal debris of the Magellanic Clouds falling to the Galaxy. Chevalier and Fransson (37.155.073) suggested a cosmic-ray supported galactic corona with an equilibrium temperature 10^4 K. Jaaniste (37.156.035) proposed a method of determining the distances of HI clouds using the equilibrium condition between clouds and surrounding hot coronal gas.

Modern sensitive detectors and new generation telescopes have been extensively used for the detailed study of distant globulars and dwarf companion galaxies. The range of metallicity of these objects is surprisingly large, several clusters exhibit anomalously red horizontal branches for their metallicity (30.154.006, 30.158.212, 32.154.005, 32.154.006, 32.154.046, 34.157.032, 37.154.076). Globular Clusters in the Local Group dwarf elliptical galaxies tend to be bluer than the halos of their parent galaxies (33.154.010). The lack of luminous red supergiants in the Pegasus dwarf irregular indicates the absence of recent star formation (31.158.036). Isochrone fitting of the Carina dwarf elliptical yields an age estimate of 7.5 Gyr and the absence of an extremely old population II component. Photometric properties and improved distances have been determined for a number of companion galaxies and their clusters (30.158.189, 32.154.003, 32.154.010, 32.158.338, 33.157.040, 34.154.030, 34.157.036, 37.154.005). Intrinsically bright carbon stars have been discovered in almost all companion galaxies (31.158.004, 31.158.042, 31.158.043, 33.157.003). New data suggest that the Sculptor dwarf galaxy has a radial velocity of +20 km/s, not -149 km/s as obtained earlier (33.157.003).

Lynden-Bell stresses that all dwarf ellipsoidal satellites of the Galaxy belong to one of two streams of tidal debris and hydrogen clouds (32.158.185, 33.157.074). Draco and Ursa Minor galaxies are oriented along the stream they belong to (31.159.006). Searches for stars associated with the Magellanic Stream have given negative results (32.159.015, 34.156.002).

The motion of companions and gaseous streams has been used to determine the total mass of the Galaxy including its massive corona. Fujimoto and Murai (37.156.031) and Lin and Lynden-Bell (31.159.002) have calculated a consistent model of the dynamics of the Magellanic Stream; the mass within a sphere of 50 kpc is 7×10^{11} $M_\odot$; see also 30.159.007. Other test bodies with less accurate results have also been used (33.155.074, 34.155.013). Einasto and Lynden-Bell (31.160.008) have calculated orbits of the Galaxy and M31 supposing that both galaxies have equal and opposite angular momenta as seen from the barycentre of the Local Group. The total mass of the Local Group lies between 4 to 7×10^{12} $M_\odot$. Tidal radii of dwarf spheroidal companions have also been used to estimate the mass of the Galaxy with controversial results (31.155.002). Miller and Smith (37.151.104) demonstrated by numerical experiments that companion envelopes become expanded by tidal encounters, rather than truncated. Thus, tidal radii cannot be used for a mass determination of the parent galaxy. Environmental influences on companion and parent galaxies have been studied in detail (32.151.081, 33.151.004, 33.151.022, 32.151.050, 33.151.059).

Shuter (29.155.001) suggested that a flat rotation curve can be produced by a disk-like population. Rohlfs (31.155.011), however, demonstrated that in respective models, the vertical gravitational force must be larger than the radial one (in the galactic plane), contrary to observations.

Carbon stars have sharp emission lines in their spectra and can be used to derive very accurate radial velocities of individual stars in dwarf ellipticals. Respective observations by Aaronson (33.157.031) indicate for these ellipticals higher M/L than that found in galactic globulars. This is used as an argument suggest-

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ing the presence of dark halos in these ellipticals (33.157.032, 33.157.033). Some Magellanic irregulars have a rising rotation curve which also suggests the presence of dark halos (Freeman, 37.156.030). The possibility that Magellanic irregulars may possess hot gaseous coronas is discussed by de Boer (37.156.061). Velocity dispersion of globular clusters in the Fornax dwarf galaxy indicates a normal mass to light ratio (34.157.030).

The possibility that dwarf galaxies may possess massive coronas can solve a dispute concerning the nature of the dark matter around galaxies. Other available evidence strongly supports a non-baryonic character of the dark matter. Non-baryonic dark matter can be made of neutrinos or particles like axions, gravitinos or photinos. In the first case, dark matter can form only aggregates comparable in mass with clusters of galaxies; in the second case, it can concentrate also around smaller objects, including dwarf galaxies and even globular clusters (Primack and Blumenthal, 37.161.268, and Peebles, 37.161.105).

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