M-TYPE DWARFS AND THE MISSING MASS

As long back as the beginning of this century, astronomers showed much interest in the determination of the mass density in the neighbourhood of the Sun by means of theoretical investigations supported by observational data. Because of the fast development of our knowledge of the structure of the Galaxy, this theoretical result has been revised by several astronomers. On the other hand, continuous improvements of the observational techniques provide a great amount of new data, making it possible to improve the calculation of the mass density. Problems recently encountered in this calculation will be summarised below.

A decade ago, Oort ("Stellar Dynamics" in *Galactic Structure*, eds. Blaauw and Schmidt, University of Chicago Press, p. 470, 1965) derived the density of matter in the solar vicinity from the velocities of stars in the direction perpendicular to the galactic plane. He noticed that this density is remarkably greater than the density which can be calculated from observed objects in that region. This discrepancy is presently known as the problem of the 'missing mass', which can be illustrated best by quoting Oort's own words: "The most probable present value for the total mass density near the Sun may be estimated at 10.0×10^{24} gm/cm^3, or 0.148 solar masses per pc^3. Of this density, roughly 40 percent must be due to stars or gas of unidentified type, and of which, therefore, we do not know the distribution in space. It is this unknown population that is the principal obstacle for deriving a model of the mass distribution of the Galaxy."

Several astronomers have tried to find the mass deficiency mentioned above, by studying the space density of M dwarfs. Because of several difficult chacracteristics of M dwarfs, i.e. low luminosity, and the difficulty of segregating them from giants, there exists discrepancies in the results of the different authors. Astronomers who having investigated the space density of M dwarfs in the region of the galactic north pole believe that they have found the missing mass in the form of low velocity M dwarfs (Murray and Sanduleak *M.N.R.A.S.*, **157**, 273, 1972), Pesch (*Ap. J.*, **177**, 519, 1972), Weistrop (*A.J.*, **77**, 366, 1972) and B.F. Jones (*M.N.R.A.S.*, **159**, 3P, 1972). However, the determination of the space density of M dwarfs in the direction of the galactic south pole is in contradiction with the above result. D.H.P. Jones (*M.N.R.A.S.*, **161**, 19P, 1973) finds a density which is a factor about ten smaller than that in the north galactic polar cap; Gliese (*Astron. Ap.*, **34**, 147, 1974) and Thé and Staller (*Astron. Ap.*, **36**, 155, 1974) determine this factor to be two to four. It is quite certain that this north-south contradiction is caused by a difference of the depth of the M dwarf surveys.

The experimental result by Murray and Sanduleak (1972), Pesch (1972) and Weistrop (1972) has created, however, an unexpected problem. These authors have found a great number of late M dwarfs with very small motions and low velocity dispersion, even lower than that of Me dwarfs. Due to their low velocity disperson, it is usually believed that Me dwarfs belong closer to population I objects than normal dwarfs. How then should the very low velocity late M dwarfs fit into this picture. This problem has been put forward by Biermann (*Astron. Ap.*, **30**, 31, 1974), Gliese (1974), Oort ("The Space Density of Faint M Dwarfs" in *Highlights of Astronomy*, ed. Contopoulos (D. Reidel, Dordrecht), p. 417, 1974) and Schmidt (preprint of paper read at the *I.A.U. Symposium No.* 69, 1974).

Let us assume that the very low velocity M dwarfs are young population I objects. Oort (1974) estimated an age of approximately 10^8 years. Since these M dwarfs carry more than 60 per cent of the local mass density, Oort questioned: "How is it then that the gas has not been completely used up long ago?" Another possibility, put forward by Biermann (1974), is to assume that the late M dwarfs, despite their low velocity dispersion, are old objects. In other words, the Spitzer-Schwarzschild (*Ap. J.*, **118**, 106, 1953) mechanism for creating large velocity dispersions does not work. But then we have to give a new explanation for the observed increase in the velocity dispersion along the main sequence from type A to K.

Recently Staller (*Astron. Ap.*, in press, 1975) has investigated the possibility of getting out from this dilemma by assuming that the group of M dwarfs, which can be detected on photographic plates, consists of normal population II dwarfs having a velocity dispersion of approximately 50 km/sec, and very young population I dwarfs with a velocity disperson around 10 km/sec, the latter have masses about ten times lower than that of the population II dwarfs. It has been shown by Kumar (*Ap. Space Sci.*, **17**, 219, 1972) that these low mass stars can exist in our Galaxy. Being on the lower part of the Hayashi track, they will be seen as M dwarfs. After some time, because of their too low mass, they will become invisible degenerate black dwarfs. Staller (1975) has calculated that the population I M dwarfs will be visible during 10^8 to 10^9 years, which means that in the lifetime of our Galaxy (5×10^9 years), about 10 generations of black dwarfs have been formed. This large group of invisible stars is probably the greatest contributor to Oort's missing mass.

Luyten (Observatory, **94**, 136, 1974) will be satisfied with this explanation, we hope, because the faint part of his luminosity function refers to the normal population II dwarfs with large velocity dispersion. Furthermore, the existence of the low velocity M dwarfs is explained without violating the Spitzer-Schwarzschild (1953) rule for creating large velocity dispersion.

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Professor D. Lal, Director, Physical Research Laboratory, Ahmedabad has been given the Federation of Indian Chambers of Commerce and Industry cash award for outstanding work in research and development and has been elected a Foreign Associate of the National Academy of Science (Washington).

Shanti Swarup Bhatnagar Prize of 1970 for Physical Science has been awarded to Dr. M. K. Vainu Bappu, Director, Indian Institute of Astrophysics, Kodaikanal, and of 1972 for Engineering Sciences to Professor G.Swarup, Tata Institute of Fundamental Research, Bombay.

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Finally, Oott's missing mass is found in the form of the presently still visible young M dwarfs, running down the Hayashi track, plus all the invisible degencrate black dwarfs.

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OSCILLATING TRANSIENT X-RAY SOURCE

X-ray sources have been known to appear in the sky, last for a few months and disappear below threshold of observability. Recently however, a transient X-ray source was observed in the Centaurus constellation, nicknamed Cen X-mas, which was above threshold of observability only for about 12 days. What makes it extremely interesting is that the emitted X-rays showed a periodicity of 6.75 minutes. These observations were made using Ariel V satellite (Eyles et al, *Nature*, **254**, 577, 1975; Ives et al, *Nature*, **254**, 578, 1975). The position of the source is right ascension $11^h\ 18^m\ 59^s \pm 13^s$ and declination - 61° 35′ 3±1″. 8. A Mira-variable and an OB star are found in the error box defined above. The obvious explanation for the X-ray source is a binary system containing a neutron star and another star, the X-ray energy is being obtained by accretion of matter from the companion star onto the neutron star; The periodicity is, similar to the binary sources Her X-1 and Cen X-3, due to the rotation of the neutron star. It is suggested (Falrian et al, *Nature*, **255**, 208, 1975) that the transient nature arises due to the pulsation period of the Mira variable which has a periodicity in the range 100-300 days; the X-ray emission is above threshold only at a certain phase of the pulsation where matter emission can be higher. Apparao and Chitre (unpublished 1975) think that the 6.75 minute periodicity is somewhat like the solar cycle periodicity for a rotating magnetic white dwarf. White dwarfs are known to have convection zones and a poloidal field twisted to toroidal bundles due to differential rotation can float to the surface to form 'star-spots'. Analogous to solar flares, magnetic field annihilation in the star-spots leads to emission of X-rays with the cycle periodicity impressed on it. The transient nature of the source can be explained by pushing the solar analogy further and suggesting that it shows similar high and low activity periods (the Sun has an 80 year high-low periodicity according to Kopcesky, *Bull. Ast. Inst. Czech.*, **13**, 240, 1963). Both the binary theory and solar cycle theory suggest that the transient source will reappear. The binary nature can be tested by looking for the expected Doppler effect.

The Ariel V satellite also found some nineteen new X-ray sources which were not there when an ealier X-ray satellite UHURU was surveying the sky. Also sixteen of the UHURU sources have 'disappeared' (*Nature*, **254**, 656, 1975). Thus it seems that there is a class of X-ray sources which are transient and if the solar cycle model is valid, many of them should show an oscillatory nature.

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ANNOUNCEMENT

An International Symposium on "Relativity and Unified Field Theory" will be held between December 1975—January 1976 at Satyendranath Bose Institute of Physical Sciences, University of Calcutta, 92 Acharya Prafulla Chandra Road, Calcutta 110 009, to mark the twentieth anniversary of significant contributions in the Unified Field Theory by late Professor S. N. Bose, the seventieth anniversary of Einstein's main paper on Special Theory of Relativity and sixtieth anniversary of the main paper on General Theory of Relativity. The participants are requested to send copies of their contributed papers, with an abstract, to Prof. M. Dutta of the Institute, so as to reach him on or before October 3, 1975.