REPORT ON THE IAU SYMPOSIUM NO. 67

The symposium on "Variables in Relation to the Evolution of Stars and Stellar Systems" was held at Moscow between July 29 to August 3, 1974. Here we present a brief resume of the week-long deliberations.

Flare stars : In his review talk, V. A. Ambartsumian pointed out that the flare activity in stars arises in the second stage of evolution of young dwarf stars $M < M_{\odot}$). As the stars appear in groups at the time of their formations, young stellar clusters and associations are the most suitable places to look for flare stars. It is now established that all stellar aggregates contain flare stars, and in each aggregate, there is a definite boundary in spectral type. Stars later than the boundary spectral type do show flare activity. In older aggregates, this boundary shifts to later spectral types. Four hundred flare stars have been detected in Pleiades, although the total number of flare stars in it has been estimated to be one thousand. Thirty flare stars are known in Praesepe and the total number of stars capable of producing photographic flares is about 150. Some statistical correlations concerning flare stars have been found out. They are— (i) the mean frequencies of flares in various flare star are different; (ii) the mean frequency of flares increases as the star becomes fainter at the quiet stage; (iii) stars in the central region of the cluster show lower mean frequencies of flares; and (iv) the absolute number of flare stars per unit magnitude interval increases towards lower luminosities. In order to prove that most young dwarf stars of a cluster in the magnitude range $10.^m5$-$12.^m5$ display flare activity, it is necessary to search for flare stars in other clusters as well as in the solar vicinity.

In the second review, R. F. Gershberg described the physical nature of the flares and compared the solar and the stellar flares. In the flare spectra, emission lines of H, He and Mg are sometimes visible. The line profiles are wide and asymmetric. The electron density in the flare regions is of the order of 10^{12} - 10^{15} electrons/cm^3 and the temperatures range from several hundred to several thousand degrees.

The continuous spectra can not be likened to black body radiation. The evidence of a corona associated with the flare activity comes through the radio observations. A theoretical model is required to explain the flare phenomenon. W. Kunkel reported peak flux levels of 10^{37} ergs/sec in the flares in early-type stars of the solar neighbourhood. The behaviour of the light variations of CC Eri, which undergoes a phase shift with respect to its orbital motion, has been likened to the BY Dra syndrome. Since hot spot models have been proposed to account for the variability of BY Dra, it is likely that similar models may represent the flare activity also.

L. Rosino pointed out that T Tauri stars can evolve to flare stage but not vice-versa. M. Rodono suggested that coordinated observations of selected flare stars in clusters should be made using recorder time resolution of less than one second. D. S. Evans reported that 4800 photometric observations of flares have been obtained by Muffet at the McDonald Observatory using high speed photometric programmes. He gave a picture of a flare star on the basis of a binary hypothesis.

Cepheids : The importance of the R-I photometric system for observing cepheid variables was emphasised due to several reasons, such as the brightness of cepheids at these wavelengths, small reddening and blanketing effects. On the basis of measurements made in the R-I system, period-colour and period-luminosity relations for cepheids were given—

$$\langle R\text{-}I\rangle = 0.20 + 0.12 \log P, \quad \pm 0.02 \pm 0.02$$

$$\langle M_R\rangle_o = -2.09 - 2.93 \log P. \quad \pm 0.12 \pm 0.12$$

It was however pointed out that it is necessary to establish a good number of standards in the R-I system. O. G. Franz gave his analysis of the double cepheid (separation=2.″5) CE Cas. Periods of $5^d\!.141$ and $5^d\!.497$ were given for CE Cas A and CE Cas B respectively. The component CE Cas A undergoes rapid fluctuations in addition to the slow one. The cause of this phenomenon is not known.

δ Scuti stars : Dealing with δ Sct stars, M. Breger in his review talk pointed out that these may be pre-main sequence stars, main sequence stars or stars leaving the main sequence for the first time in the spectral range A to F. They have masses lying between 1-2 $M_{\odot}$, typical light amplitudes of $0^m.02$ and periods $0^d.25$. The δ Sct type variability can occur in young as well as in old clusters. In the observed instability strip, there are many non-variable stars lying side by side with the variables. These may be the stars either having very small amplitudes of light variations or stars in which pulsation has been inhibited by rotational velocity and/or metallicity. Preliminary results of the abundance analyses of δ Del and F IIIp stars now being carried out at the University of Texas show that (i) the Ca and H line profiles in many δ Del/F IIIp stars are normal and (ii) rare earths in δ Del/F IIIp are overabundant by a factor 3 compared to the normal stars. If these abundance-anomalies are proved to be real, then it would mean that metallicity and pulsation can coexist in a certain temperature and gravity range. The Q values of δ Sct stars computed on the basis of their average periods show that like in RR Lyr stars, hotter variables ($T > 7800$°K) pulsate in the first or second harmonic mode and the cooler ones ($T < 7800$°K) in the fundamental mode.

D. H. P. Jones compared the properties of δ Sct and AI Vel type stars, and showed that the masses of these two groups differ by 0.7 in log M, AI Vel group having the lower mass.

A. A. Pamjatnykh has been carrying out linear-non-adiabatic analysis of radial pulsations in the fundamental, first, second and third harmonics.

In the discussion on δ Sct variables, the period variability of 44 Tau, and a period-luminosity relation of the type $M_V = -1.3 - 4.5 \log P$ for dwarf cepheids and δ Sct variables were pointed out.

Wolf-Rayet stars: S. V. Rublev in his review paper on W-R stars stated that single W-R stars are formed when massive (20-30 $M_\odot$) stars, having reached the red supergiant region in the course of their evolution, develop an inverse density gradient, and consequently eject the hydrogen rich envelope, leaving behind a hot helium remnant of mass $\simeq 10 M_\odot$. The W-R stars of a binary system are believed to be formed by the mass exchange between the components as they evolve. The temperatures of these stars are $\backsimeq$ 80,000°K.

Novae: E. R. Mustel gave a model in terms of a binary system to account for the formation of the gaseous disc around the hot companion. The over-abundance of C, N, O in the novae envelopes was explained by surface thermonuclear reactions taking place in the disc. Large magnetic fields were invoked to produce explosions. Gorbatsky, however, put forth the suggestion that thermal winds may be responsible to carry the energy to the surface of the start to produce explosions.

R. Tylenda discussed spectra of Nova Delphini taken in 1969. He had found 6 components in the profile of H_β. N. Vogt reported photoelectric observations of the dwarf nova VW Hya. He has determined a period of 0.07427111±6 days for the light fluctuations.

U Geminorum stars: V. G. Gorbatsky reviewed the present status of the knowledge about U Gem stars. The activities of U Gem stars have been explained again by invoking close binary systems. According to the model suggested, both components of a U Gem stars are dwarfs. One is a dwarf of late spectral type (G or K) and the other a white dwarf, having masses $M_\odot$ and $1.2M_\odot$ respectively. At the light minimum, the line spectrum consisting of broad-intense hydrogen emission line is formed in a gaseous disc surrounding the white dwarf companion. This disc is sustained by a supply of gas in the form of a stream from the other component. During the impact of the gaseous jet with the disc, energy of the order of 10^{31} ergs/sec is released from the region of impact. As the jet is turbulent, the energy output from the hot spot is not constant but fluctuates by slight amount causing the small rapid oscillations in the light curves of these stars. The large out-bursts are believed to be caused by the heating and expansion of the cool dwarf companion. The convection zone in the cool dwarf could also lead to instability. According to Ivanov, the flux of energy transported by convection may be lowered by gravity, and therefore this energy may be stored at the inner boundary of the convection zone. The time of growth of instability in such cases is $\simeq 10^7$ sec. This corresponds to the duration of the cycles of U Gem type out-bursts. The changes in the orbital periods of many U Gem stars could be due to the presence of a third body. The origin of U Gem stars has been likened to that of the W UMa type stars.

Symbiotic stars: A. A. Boyarchuk in a brief review mentioned that symbiotic stars are binaries having a red giant as a companion. They belong to old disc population. The symbiotic object V1016 Cas was reported to have increased in magnitude from $15^m.5$ to $10^m.3$ during 1963-71. High ionisation potential lines He II, Fe V, Fe VII, Ne III, Ar V are observed in emission. TiO and VO absorption features are also present in absorption. O. E. Mandel reported UBV photometry of V1329 Cyg. He has found long period variation of 508 days and a magnitude variation of $1^m.0$ At maximum, M type spectrum is obtained. During envelope phase, flares also develop. Emission lines appear after light maximum. A. Mammano discussed image tube spectra of symbiotic stars CI Cyg and Z And. After the outburst, lines of He II, O III, He I, Fe VII become evident. In CI Cyg, molecular compounds never disappear, although TiO reduce in intensity after the outburst.

RR Lyrae and W Virginis stars: B. V. Kukarkin posed several problems connected with RR Lyr and W Vir stars. The obvious difference between the period-frequency diagrams of RR Lyr stars in dwarf galaxies, globular clusters and the galactic field points out to the fact that RR Lyr stars of period $<0^d.42$ found in the galactic field should have a origin different from the RR Lyr stars in other systems. The metallicity parameter $(k\text{-}b)_2$ for galactic RR Lyr stars correlates with the inclinations and eccentricities of their galactic orbits, in that the metal rich stars have small i and small e whereas metal poor stars may have any values of i and e.

Another interesting aspect is the question as to why RR Lyr stars are found in some globular clusters and are entirely absent from some other clusters having the same type of colour-magnitude diagram.

One more field of study should be to investigate all stars lying inside the instability strip, particularly at the boundaries. Studies of the period changes in RR Lyr as well as W Vir stars constitutes yet another problem. Thorough investigations of selected RR Lyr stars in nearby globular clusters should also be carried out using multi-colour photometry or spectroscopically.

In case of W Vir stars also, at least two distinct groups have been recognised. Radial velocities of W Vir stars should be studied to learn about their kinematics. More stars in globular clusters should be observed in order to classify these stars according to their properties.

V. P. Cessevitch pointed out the need to extend observations of RR Lyr stars to southern hemisphere, to repeat the work of Preston and Spinrad with the presently available material, and to extend the work of Oke for several stars to define a temperature scale for RR Lyr stars.

Quasi-Stellar Sources: T. D. Kinman emphasised the association of a non-thermal radiation source with QSO. The size and variability of this non-thermal source are important for understanding the physics of these objects. For BL Lac, a red shift of 0.07 was reported. This value of the red shift is typical of ordinary E galaxies.

V. M. Yutuj talked about the variability of the nuclei of Seyfert galaxies. Quasars and nuclei of Seyfert galaxies are perhaps of the same origin. He also presented observations of the nuclei of Seyfert galaxies, taken in U light. For NGC 4151, two components of variability were found—a slow component and a rapid component. In NGC 1275 rapid variability alone has been found so far, but a detailed analysis is awaiting. NGC 1065, NGC 4051 and NGC 7469 have also been found to have variable nuclei. I. I. Pronik showed line profiles of H_α, H_β, H_γ, and H_δ in the spectrum of NGC 7469 taken at a dispersion of 380Å/mm. H_α line is narrower in width than other lines. The line profiles are variable from day to day.

X-ray stars: H. Gursky in his review, indicated, that on the basis of available data it is now safe to conclude that in the life of every X-ray source, a supernova explosion had been involved, resulting in the formation of a binary system with one component being a neutron star or a black hole.

Two types of X-ray sources can be distinguished, one lying almost in the galactic plane (Cyg X-1, Cen X-3, 0900-40, 1700-37, SMC X-1) and the other rather off the plane (Sco X-1, Cyg X-2, Cyg X-3 and Her X-1). The former are all identifiable with O and B supergiant stars with large masses while the latter are low mass stars of population II. The favoured location for all these systems is in the inner sides of spiral arms.

R. A. Sunyaev discussed X-ray pulsars among X-ray sources and explained the phenomenon on the basis of a fast rotating oblique rotator model for the neutron star/black hole.

C. S. Bowyer in a discussion of the problems of optical identification of X-ray sources pointed out that in the absence of establishment of optical co-variability, UV excess and the spectrum of the star could be used as indicators. As an illustration, the case of 340614+09 was discussed.

W. Krzeminski discussed the X-ray star Cen X-3 and on the basis of available data put its spectral classification as B0-III.

A series of papers dealing with polarization in X-ray stars followed. A. B. Severney and V. M. Kuvshinov measured circular polarization of -4.34 ± 0.23 per cent and -2.60 ± 0.16 per cent. respectively in B and V filters for the star Sco X-1, while in Cyg X-1 no significant polarization was observed. The result for Cyg X-1 was confirmed by O. S. Sulov who measured the polarization for the star at six wavelengths between λ 3400 — λ 6900. Only at λ 6300 a statistically significant circular polarization of about 0.7 per cent was observed. Yu. S. Efimov suspects some linear polarization in Her X-1, though his results are still below the level of statistical significance. Thus polarization in these stars looks probable, though still not confirmed.

This was followed by papers of theoretical nature on models for X-ray stars. N. I. Shakura discussed the theoretical light curves of X-ray binary systems in which the larger component fills its Roche lobe, for different values of the mass-ratio and inclination.

G. S. Besnovatyj-Kogan and B. V. Komberg proposed a model for Her X-1 based on jets streaming out of the optical component and following its magnetic lines of force. The 35^d period in X-ray emission was sought to be explained in terms of the neutron star being or not being in these jets during the course of its orbit around the optical component.

A. I. Tsygan proposed a binary model for the pulsar component of the Crab nebula, with elements $M_1 \simeq 0.6\ M_\odot$, $M_2 \simeq 1.8\ M_\odot$, $T \simeq (100\text{-}600)$ yrs, $a \simeq (4\text{-}15)\ 10^{14}$ cm, $a\ (1\text{-}e) \simeq 10^{12}$ cm.

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REPORT ON THE I. A. U. SYMPOSIUM NO. 69

The International Astronomical Union Symposium No. 69 on "Dynamics of Stellar Systems" was held in the Observatoire de Besancon at Besancon, France, between September 9-13, 1974. About sixty scientists participated in the symposium.

The scientific programmes covered stellar systems of various degrees of flattening from spheres through disks. It did not however include the dynamics of spiral structure. Although the emphasis was on theory, the comparisons of theory with observations and with numerical simulations played an important role. Eleven review papers and 29 contributed papers were given. Apart from discussion after the papers, there was much time for informal discussion. At the conclusion of the symposium, Dr. Lynden-Bell symmarized the important results presented at the symposium.

It was emphasized by King and Lynden-Bell that the key to the theoretical interpretation of the various forms of galaxies lies in our understanding the process of star formation. This aspect of astrophysics therefore deserves great attention.

There was much discussion on the dynamics of a globular cluster. Spitzer discussed how mass stratification takes place in the cluster during its dynamical evolution; the stars of heavy mass move towards the centre while those of lower mass are either expelled from the cluster or are driven away to the halo. He pointed out that the rate of escape of stars, particularly of the low mass stars, is considerably increased by the external forces. The structure of a globular cluster is also affected by the gravitational shocks experienced by it during its passage through the galactic plane. Stressing the role of observations in orienting the theory, King pointed out that the observations indicate that the limit of globular clusters is determined by the gravitational field of the galaxy. The velocity distribution in a globular cluster differs from the Gaussian due to the cut-off at a certain velocity. Observations help us to decide how the cut-off occurs.

It was generally felt that the formation of binaries plays a prominent role in the dynamics of a star cluster. Aarseth reviewed the results of N-body simulations and pointed out that stellar systems with small N evolve until they are eventually dominated by a central binary. Stars coming close to this binary may be ejected from the