WINTER SCHOOL ON HIGH ENERGY ASTROPHYSICS

The Tata Institute of Fundamental Research recently sponsored a Winter School on High Energy Astrophysics. The School was held in Bomday from January 5 to16, 1976 and was attended by about 75 participants including many from all over India. There were four lecturers : Professor Geoffrey Burbidge, Dr Judith Perry, Professor G. T. Zatsepin and Professsor J. P. Ostriker. Besides, there were a number of seminars on related topics by some of the participants and a panel discussion.

Burbidge and Perry gave an interlinked set of lectures on the physical properties of radio sources, QSOs and the BL-Lac type objects. Perry concentrated mainly on the optical properties while Burbidge dealt with the radio ones. Perry showed a number of slides to discuss the magnitudes, colours, spectral characteristics and time variations. The N-galaxies resemble the QSOs in their compactness of nuclei, whereas the BL-Lac type objects show almost a total lack of line spectra. The number of QSOs with emission line redshifts is now as large as 498, of which some 86 have absorption line systems. There are 93 compact non-QSO type objects (largely N-galaxies) with emission line redshifts. (These numbers may be out of date by now, considering the rapid growth of this field). Perry discussed possible explanations of the emission lines and the absorption lines, in particular the radiation drive mechanisms. Burbidge discussed the redshift problem emphasizing the fact that no known explanation seems to account for all the detailed spectroscopic results about QSO redshifts. He also outlined the present ideas of non thermal emission in radiosources. Here again, there are a number of questions still to be resolved, such as the details of radio soure structure, the energies, the role of the optical object often identified with the radio source, etc.

Ostriker described the general evolutionary pattern of stars in various mass ranges with their characteristic end-products which are summarised in Table 1.

In the review of supernova hydrodynamics Ostriker emphasized the need for some storage device like a rotating neutron star for powering Type II Supernova and discussed the role of circumstellar envelope in blocking the outgoing radiation.

While discussing the physics of galactic X-ray sources Ostriker pointed out that the energy source for powering these is most likely the process of accretion onto a compact object in a binary system either by the companion blowing intense steller wind or by the Roche overflow. However, he emphasized that there are limits to the amount of matter collected as the flow can be throttled by a combination of the following factors: radiation pressure, heating and cooling of the gas, the presence of a magnetosphere around the compact star. The nature of the flow, how it is stopped and the resultant X-ray emission are determined by a variety of considerations, e.g. the possible presence of an

Table 1

Mass Range	Mass in the galaxy	Lifetime	Death rate	Remnant
	($M_\odot$ pc^2)	(Yrs.)	(pc^{-2} yr^{-1})	
$M/M_\odot \lesssim 0.7$	70	$10^{10\cdot2}$	—	—
$0.7\pm1 \lesssim M/M_\odot \lesssim 4\pm1$	7	10^8-10^{10}	2×10^{-9}	White dwarfs
$4\pm1 \lesssim M/M_\odot \lesssim 9\pm1$	10^{-3}	$10^{7\cdot5}$	4×10^{-11}	Neutron stars (no violent explosion)
$9\pm1 \lesssim M/M_\odot \lesssim 30\pm7$	3×10^{-5}	10^7	6×10^{-12}	Neutron stars (explosive nucleosynthesis, main chemical processors in the galaxy)
$30\pm7 \lesssim M/M_\odot \lesssim 100\pm30$	3×10^{-7}	$10^{6\cdot5}$	2×10^{-13}	Black holes

accretion disc around the compact object, standing shock wave, magnetic funnelling near the polar regions when there is a strong magnetic field as in the case of neutron star. There is also the problem of the stability of an accretion disc which is found to depend rather sensitively upon the underlying assumptions about the viscosity. The recent work of Shu in fact questions the turbulent nature of the flow in the disc which is shown to be largely laminar in character. If this should indeed be the case, the radiation would result not from viscous dissipation in the disc, but rather from spherical accretion or some such source of gravitational energy release.

The recently discovered globular cluster X-ray sources, according to Ostriker, can be satisfactorily explained by postulating central massive ($\sim10^3$ M$\odot$) black hole cores in globular clusters.

Zatsepin described the Russian work on the gravitational collapse caused by the dynamical instability of massive stars during advanced stages of evolution. The collapse may result either in the formation of a neutron star with the excess mass thrown off or in the formation of a black hole. The computations of gravitational collapse are performed in the framework of hydrodynamical equations in Lagrangian form, by including neutrino energy losses, in particular the URCA-process which dominates all other processes. On the basis of hydrodynamical calculations it was concluded that for the central density $\rho_c \lesssim 5\times10^9$ gm cm^{-3} there is no gravitationally bound remnant (e.g. a neutron star) left behind, while for $\rho_c \gtrsim 5\times10^9$ gm cm^{-3} the gravitational collapse leads to the formation of a neutron star and a simultaneous supernova outburst due largely to the deposition of neutrinos and the consequent burning of carbon in the envelope of the collapsing star.

Zatsepin discussed various mechanisms for generating pulsed gamma-ray emission and neutrino radiation during late stages of stellar evolution, and described the methods for detecting neutrinos from collapsing objects. Regarding the possibility of detecting collapses in other galaxies, Zatsepin pointed out that statistically approximately one neutrino event per year is expected from these and for detecting such a flux one needs a very large ($\sim 10^6$ ton) detector. The prospects of detecting the neutrino flux from collapsing stars in other galaxies are thus very dim.

S. M. Alladin gave a seminar on the gravitational interaction between galaxies, its role in determining the various galactic shapes seen in the universe and in enriching the intergalactic medium within a cluster. S. Naranan talked on the soft X-ray spectra of Sco X-1 and Crab Nebula and R. K. Varma discussed the critical velocity for the interaction of plasma with neutral gas. V. K. Kapahi gave a seminar on the angular size-flux density relation of radio sources derived on the basis of the Ooty data on lunar occultation measurements, and argued how the data supports an evolutionary cosmological model. J.V. Narlikar described the results of investigations by P.K. Das and himself of high central gravitational redshifts from compact objects with a view towards understanding the nature of QSO redshifts. The seminars by two passing visitors—Professor Hertzberg (on a spectroscopic problem of interstellar interest) and Professor Poonamperuma (on prebiotic chemistry) blended well with the general lecture schedule of the Winter School.

Towards the end a panel discussion on Cosmology, chaired by J.J. Perry, generated considerable interest. The panelists included J. P. Ostriker and G. Swarup (seated on the *right*) and G.R. Burbidge and J.V. Narlikar (seated on the *left*). The over-all question under discussion was whether the universe is evolving. Ostriker and Swarup voiced the conservative views of the majority of the astronomers that by now the evidence is strong enough to answer the question in the affirmative. Burbidge and Narlikar played the devil's advocates and pointed out the various 'ifs' and 'buts' in the present evidence. There was a good deal of participation from the floor.

G.R. Burbidge's public lecture on 'Violence in Astronomy' was part of the Winter School programme. Burbidge presented evidence for violent activity mainly in the nuclei of galaxies but refrained from theorizing about the same.

This was the third School of its kind arranged by the Tata Institute. The previous two were in 1972 and 1966.

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