635, 1977). These have an average lifetime of 4×10^6 years, derived from their characteristic age and migration velocity. Together, these give a pulsar creation rate of about 1 every 8 years, greater than the supernova rate of 1 every 20 to 100 years. Thus, there appears to be more pulsars created than supernovae, although no other birth mechanism for pulsars is known which would provide the high migration velocity (150 km s^{-1}) and scale height (400pc). The problem would be relieved if the Galactic electron density was 0.02 cm^3 instead of 0.03 cm^3, or if pulsars could be created in supernovae that did not create optically visible remnants. However, Hefland's work with the Einstein satellite (*IAU Symp.* **95**, Bonn Aug. 1980) shows that many young supernova remnants do not contain pulsars, thus making the problem worse.

Van Paradijs (University of Amsterdam, MIT) provided a lucid review of X-ray bursters. Dividing the binary galactic X-ray sources according to the ratio of their X-ray and optical luminosities gives two distinct types of X-ray emitters:-

(1) L_x/L_{opt} less than 10; primaries are O,B stars $M_v \sim -5$, hard X-ray spectra, X-ray pulsars, X-ray eclipses common. (2) L_x/L_{opt} greater than 10, primaries are 'Sco type', $M_v \sim +3$, soft X-ray spectra, busters.

A typical burst will have a rise time of 1 second and a decay time of 10 - 60 seconds. There are, however, two types of burst activity. Type I bursts are seen from all bursters, they occur every couple of hours and their spectra soften during decay. Type II bursts are only seen from the 'Rapid Burster' (MXB 1730-335), which also exhibits type I burst activity. The type II bursts occur about every 10 seconds and have spectra which do not soften. The energy of a type II burst is proportional to the time from the previous burst, implying accretion build up and overflow.

The estimate of 1 - 5 $M_\odot$ for the mass of the X-ray emitter and the estimated radius of the emission region (10 km) have given rise to a successful model for type I bursts. In this, the X-ray emission is due to thermo-nuclear flashes in the helium rich material on the surface of a neutron star, this being accreted from a binary companion.

This model describes the bursts well, with the bursts ceasing if the accretion rate is so great as to cause continuous nuclear burning. Until recently there was no evidence for the binary nature of the bursters but, recent spectral observations of the optical counterparts suggest a companion to CenX-4 (*IAU* circ. 3487), and an accretion disk in AO620-00 (Murdin *at al. MNRAS* **192**, 709; 1980). The optical counterparts of these stars, and of A1742-28, are K type stars.

Correlated optical bursts have been seen in three sources so far. (1735-44, 1837 + 05, 1636-53; Van Paradijs). The energy of the optical bursts is 5 orders of magnitude lower than that of the X-ray bursts and are thought to be due to reprocessing of the X-ray flux. There is a 2 second delay between the X-ray and the optical bursts, reprocessing might cause a delay of 0.5s so the implied distance to the re-processing site is 1.5 light seconds. It is expected that the reprocessing occurs around the edge of an accretion disk, the size of which implies a neutron star companion of $0.4M_\odot$ consistent with K-type stars.

Pederson (ESO) reported optical and X-ray coverage, noting one slow burst (rise time 3-4 sec) in optical and X-ray from MXB 1636-53, and one fast optical burst (rise time less than 200 msec) from MXB 1735-44, for which there was no X-ray coverage. Infra-red bursts from the 'Rapid Burster' were described by Jones (Imperial College). This group has discovered very bright bursts ($m_k \sim m_h \sim 6$) of $\sim$10 sec duration with fast flashes (some less than 0.3 sec) superimposed. These bursts are only an order of magnitude less intense than the X-ray bursts, but do not follow the known type I or type II behaviour.

Walker (RGO) has been studying the blue light curve of the black hole candidate Cyg X-1 over the past 8 years. He has found that the light curve and period have varied. A periodic change is suggested, such as a third object (period > 18 years) or precession of either of the known components.

His most recent data showed a dramatic change in the light curve. The primary maximum had decreased and the secondary maximum had increased and attained a double structure. This behaviour had been seen once previously, just before an X-ray transition. Evidently, an X-ray transition did take place between mid May and early June of this year (*IAU* Circ. 3491).

Shklovsky (Space Research Institute, Moscow) described his model of the peculiar object SS433, as an O,B super giant with an extreme stellar wind (10^{-4}m yr^{-1}) in a binary system with a neutron star of low magnetic field at the centre of an accretion disk. These are surrounded by an expanding cloud, optically thick to infrared radiation. The moving lines are reproduced by blobs which become optically thin to Hα as they are blown from the accretion disk onto the circum-system cloud. These blobs become shocked and heated to 10^{7-8} K to produce X-rays.

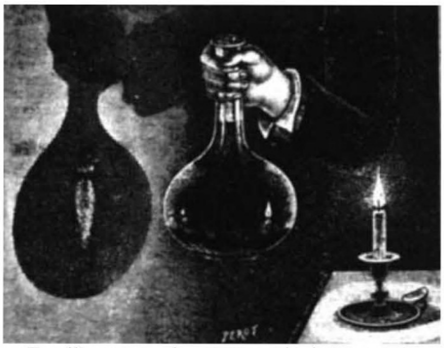
King (University of Leicester) confirmed a previous X-ray iron line detection, and suggested a change of the X-ray continuum; no periods were found in the range 1-200 days, despite considerable X-ray variability. The infra-red flux is also variable ($\Delta M = 1.6$), the IR colours however, remain constant. There is a suggestion of an 11.8 day IR period, but no period was seen at 13 days.

Observations of SS433 reported by Schilizzi (Dwingeloo Radio Observatory, Holland) showed milli arcsec variation within 6 months. At a larger scale, Spencer (Jodrell Bank) described the radio structures as consisting of an unresolved central core (less than 0.3″) with a flat spectrum and a 3″ halo with a spectral index of —1.1, elongated in the direction of the SNR W50. He noted a 1 week flare in the core which was not seen in the halo.

Ciatti has undertaken a study of moving lines, observing that they vary irregularly in intensity and wavelength, sometimes forming multiple systems. He notes that the velocity and angle of the jets varies night by night whilst following the general precession. His best fit period is 165.5 days, using 200 nights observations over 3 cycles. The intrinsic colours of SS433 lead Firmani (Instituto de Astronomica, Mexico) to conclude that the primary is an early type star intermediate between Of and WN8. These stars are of 15 $M_\odot$ burning helium in

100 years ago

PHYSICS WITHOUT APPARATUS



To illustrate the geometrical laws of refraction through lenses, a good reading-glass of large size is a desirable acquisition. Spectacle-lenses, though of smaller size, and therefore admitting less light, are also of service. In the absence of any of these articles, it is generally possible to fall back upon a water-decanter, provided one can be found of a good globular form, and not spoiled for optical purposes by having ornamental work cut upoin the sides of the globe. The figure shows how this decanter, filled with water, is to be employed. It is held a few inches away from a white wall, and a candle is placed at the opposite side, so that its light falls through the decanter on to the wall. The candle is moved towards or away from the decanter until the position is found in which its rays focus themselves upon the wall giving a clear inverted image of the candle flame upon the wall. The experiment may be varied by setting down the candle on the table and then moving the decanter to and fro until a definite image is obtained. If a large hand reading-glass be available, the image will be much clearer than with the improvised water-lens; and a further improvement in the manner of experimenting may be made by using a screen of white paper or card instead of a whitened wall on which to receive the image.

From *Nature* **22**, 7 October, 541 & 537, 1880.

0028-0836/80/410485-02$01.00