speckle interferometry and interferometry with multiple systems were extensively discussed together with the theoretical limitations of these techniques. Then the needs for high angular resolutions in all fields of astronomy from the solar system to the galaxies have been presented.

Good arguments have been given for both solutions, single and multiple apertures. Some lively discussions on this subject have shown that any decision would be premature.

The workshop proceedings will be published by ESO in a few weeks. *P. V.*

PERSONNEL MOVEMENTS

STAFF

Arrivals

Europe

FLEBUS, Carlo, I, Laboratory Technician, 1.5.1981
MÜLLER, Karel, DK, Administrative Assistant (Accounting), 1.5.1981
TANNE, Jean-François, F, Project Engineer in Astronomical Instrumentation, 1.7.1981
HUSTER, Gotthard, D, Designer-Draughtsman, 1.7.1981
MEYER, Manfred, D, Electronics Engineer, 1.10.1981
KRAUS, Hans-Jürgen, D, Driver/General Clerk, 1.7.1981
MALASSAGNE, Serge, F, Designer-Draughtsman, 1.8.1981
PONZ, José, E, Science Applications Programmer, 1.10.1981

Departures

Europe

SCHULTZ, Raimund, D, Driver/General Clerk, 15.5.1981
SCHABEL, Peter, A, Senior Electr. Engineer, 31.8.1981

ASSOCIATES

Departures

Europe

LINDBLAD, Per Olof, S, 31.8.1981

FELLOWS

Arrivals

Europe

BJÖRNSSON, Claes-Ingvar, S, 1.10.1981
GILLET, Denis, F, 1.10.1981
WOUTERLOOT, Jan, NL, 1.10.1981

Departures

Europe

PAKULL, Manfred, 31.5.1981

Photometric, Spectroscopic and IUE Observations of X-ray Binaries

H. Mauder, University of Tübingen

Introduction

X-ray binaries offer the unique opportunity to study the properties of neutron stars in some detail. In a recent article E. J. Zuiderwijk (THE MESSENGER No. 19, p. 18, 1970) discussed the "Standard Model" of X-ray binaries with massive components, demonstrating the difficulties in lightcurve analysis and mass determination. The model is relatively simple: a normal primary star, which can be observed in visual light, and a neutron star form a binary system. The most important constraint is given by the "Limiting Roche Lobe", a critical surface, which is confining the maximum possible radius of the primary star. The size of this lobe, in units of the separation of the two stars, is dependent only on their mass ratio. Thus the radius of the primary star gives a limiting value for the mass ratio.

It is assumed that the optical star is in bound rotation, which means that the rotational period of the star is identical with the orbital period of the binary system. Thus, the orientation of the star relatively to the axis connecting both components is constant, an assumption which seems quite plausible due to the strong tidal deformation in very close binary systems. If, however, the primary star shows unbound rotation, then the size of the limiting lobe is different from the normal case of bound rotation and as a consequence, a different value for the mass of the neutron star is possible.

Another problem is the mass transfer, which is necessary to make the binary star an X-ray binary. The kinetic energy of the gas falling onto the neutron star is converted into heat, at the surface of the neutron star a temperature of about 10^7K is reached, giving rise to strong X-ray emission. There are two possible mechanisms for the mass transfer: Either the primary star, due to its evolution, has expanded up to its limiting Roche lobe and the matter overflowing this lobe is falling on the neutron star, or the primary star loses mass due to a strong

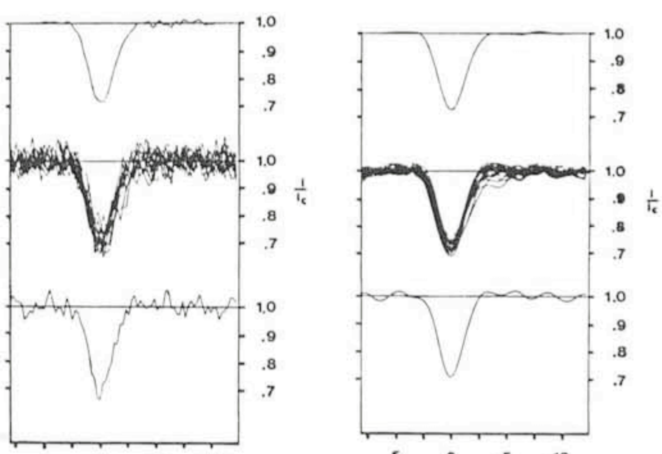

Fig. 1: *The He I 4026 Å line of Vela X-1. Left part: uncorrected line profile. Right part: Corrected for high frequency noise. Bottom: profile of a single line. Middle: profiles of all the 14 spectra used. Top: mean profile.*

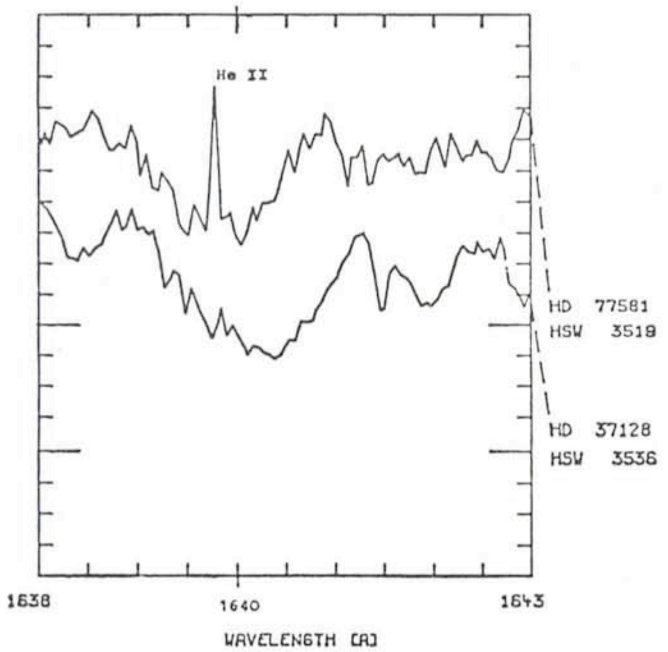

Fig. 2: *A comparison of the He II 1640 Å line profile of Vela X-1 (top) and HD 37128 (bottom). The rotational broadening is very similar in both stars. The spike in the Vela X-1 spectrum is due to an error (saturated pixel) in the image transmission from the satellite to the earth.*

stellar wind. In massive X-ray binaries, the second case seems to be present. Thus, a detailed study of the properties of the stellar wind will give information on the connection with the X-ray emission.

The Unbound Rotation of Vela X-1

According to the results cited by Zuiderwijk, the equatorial velocity of the optical component in Vela X-1 should be v_{eq} sin i = 175 km/s in the case of bound rotation, where i is the inclination of the axis of rotation against the line of sight. This rotational velocity should alter the profiles of the spectral lines and it is possible, therefore, to derive the value v_{eq} sin i from the line shape (Fig. 1). As an example, the He I 4026 Å line of Vela X-1 is shown, from Coudé spectra taken with the ESO 152 cm telescope at 20 Å/mm. Using the Fourier Transform Method it is possible to correct the intensity tracings of the spectra for the high frequency part of the photographic noise. In the left part of the figure, the uncorrected tracings are shown, in the right part the corrected ones. Bottom is a single line, the middle gives the tracings of all 14 spectra used and at the top the mean line is shown. Applying a Fourier-Bessel-Transformation on these line profiles gives the velocity v_{eq} sin i. This was done for several He I lines; as a result, v_{eq} sin i = 89 km/s was obtained for Vela X-1. Details of this procedure are described by M. Ammann and H. Mauder (*Mitteilungen Astr. Ges.* **43,** 219, 1978). In addition, the EUV spectra of Vela X-1 and of HD 37128, taken with the IUE satellite, are compared (Fig. 2). HD 37128 is a B0 Ia supergiant, almost exactly the same spectral type as the primary star of Vela X-1, and is known to have a rotational velocity of v_{eq} sin i = 85 km/s. The shape of the He II 1640 Å line is very similar in the spectra of both stars. Thus it can be expected that the rotational velocities are not very different, though the effects of a stellar wind are also important. It is evident, however, that the rotation of the optical component of Vela X-1 is much slower than expected for bound rotation. The rotational critical lobe of the primary star of Vela X-1 is larger than the respective Roche lobe for a given mass ratio; therefore, the minimum mass ratio may be smaller than in the case of bound rotation. As a consequence, the minimum mass of the neutron star in Vela X-1 could be somewhat smaller than 1.74 solar masses.

Stellar Wind

The profiles of spectral lines may be altered remarkably if a strong stellar wind is present. The gaseous matter surrounding the star produces the well known P Cygni line profiles, strong emission lines with violet shifted absorption features.

The line profiles may be very different, according to ionisation, wind velocity and density. As an example, the 1403 Å Si IV line of X Per is shown (Fig. 3), taken from an IUE

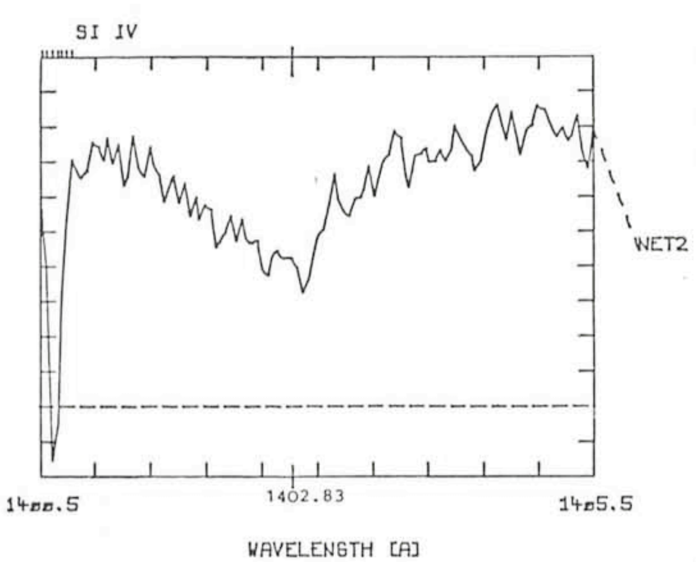

Fig. 3: *Si IV 1403 Å line of X Per. The line profile is very asymmetrical, showing an extended violet wing. This wing indicates a stellar wind of about –350 km/s.*

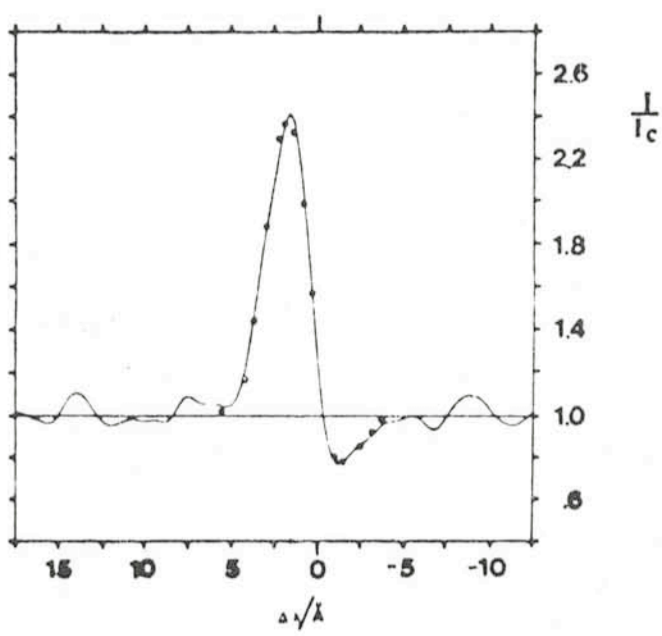

Fig. 4: *Theoretical (dots) and observed (full line) profile of the Hβ line in WRA 977. The physical characteristics of the stellar wind zone surrounding the primary star can be derived in detail from the P Cygni line profile.*

spectrum. Due to the combined effects of emission and absorption, the line is very asymmetrical with a large, violet shifted wing, indicating a wind velocity of about –350 km/s. Further analysis of the EUV spectra will give information on the rate of mass transfer in this X-ray binary system. Another good example is WRA 977 = 3U1223-62. 20 Å/mm Coudé spectra, taken at ESO, show typical P Cygni profiles. Theoretical calculations for the Hβ line give excellent agreement with the observed line profile (Fig. 4). For details see H. Mauder, M. Ammann and E. Schulz *(Mitteilungen Astr. Ges.* **43**, 227, 1978). It is interesting to note, that the stellar wind in WRA 977 must be remarkably variable: spectra, which were taken in 1979, show little or no emission, only the normal absorption components of the Balmer lines are seen.

Optical Burst in Sco X-1

One of the most exciting new groups among the X-ray sources are the X-ray bursters. A review on these objects was given recently by W. Wamsteker (THE MESSENGER No. 18, p. 31, 1979). Optical bursts have been observed from some of these sources, too (see for instance H. Pedersen, THE MESSENGER No. 18, p. 34, 1979). It is now generally believed that the X-ray bursts – and also the optical bursts – are due to a thermonuclear flash on the surface of a neutron star. In normal X-ray binaries, the matter accreted by the neutron star will undergo nuclear burning similar to the processes in stellar interiors. The hydrogen is transformed to helium, helium to carbon and so on until a distribution of elements similar to the equilibrium process is reached. However, in special cases the temperature and pressure at the surface of the neutron star may be too low for this process to take place. The infalling hydrogen is transformed to helium, but helium burning cannot start. Therefore, more and more helium is accreted, until the temperature and pressure reach the ignition point for helium burning: the helium bomb will explode, leading to the burst. The optical identification of some X-ray bursters showed that these objects are very similar to Sco X-1. The spectra of the X-ray burster MXB 1735-44 and of Sco X-1 are almost identical, even in details. However, no X-ray bursts were detected from Sco X-1 till now, though its X-ray emission is very irregular. In a series of photometric observations, obtained at La Silla with the 1 m telescope with a time resolution of two seconds, an optical burst of Sco X-1 was found on March 13th, 1979, 7^h 29^m 49^s U.T. (Fig. 5). The short duration of only about ten seconds is typical for burst events. Thus, Sco X-1 may be the connecting link between X-ray bursters and normal, low mass, X-ray binary stars.

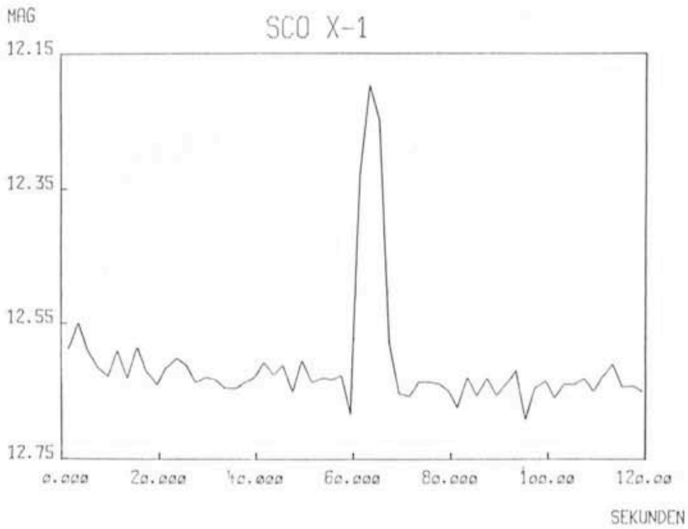

Fig. 5: *Sco X-1 showed a burst event in the optical range on March 13th, 1979, at 7^h 29^m 49^s U.T. This is an indication that the X-ray bursters are very similar objects.*

Millimetre Observations of Quasars

W. A. Sherwood, Max-Planck-Institut für Radioastronomie, Bonn

During an observing run on La Silla in 1978 I noticed a preprint from Wright & Kleinmann concerning their recent infrared (IR) observations of a very luminous quasar, Q0420-388. It had been discovered at Cerro Tololo on objective prism plates by Osmer and Smith. There were several aspects of this object which interested me: it had a large redshift, z = 3.12, and yet its apparent magnitude was brighter than 17 implying a very large luminosity (3C 273 has an apparent magnitude of 13 and z = 0.158); it was not then known to be a radio source (< .22 Jy at 2.7 GHz); and yet the IR and visual intensity gave a shape to the spectrum which would soon reach a value larger than the radio limit if the spectrum were to be extrapolated to frequencies lower than the IR. In fact, extrapolating the spectrum to 1 mm or 300 GHz yielded a flux density greater than 1 Jy which I thought we could measure.

In the submillimetre group of Georg Schultz at the Max-Planck Institute the first successful tests of our composite bolometer system were made in 1978. Ernst Kreysa attended to the cryogenics and electronics, and Michael Arnold put the high and low pass filters together to insure that only radiation at 300 GHz could be measured. Recently Peter Gemünd has made further improvements in the transmission characteristics of the filter.

As is well known, the first quasars were discovered through their strong radio emission which led to their being identified with star-like objects with ultraviolet excess and strong emission lines.

This led to two optical methods, 2-colour photography and objective prism spectroscopy, for finding quasars. For comparison the majority of those found optically (~ 90 %) were either very weak radio sources or were not detected (radio quiet).

This result was certainly unexpected, bearing in mind that it was the strong radio emission which led to the discovery of quasars in the first place.

Are the radio-loud and -quiet quasars intrinsically or extrinsically different?

Intrinsic – most of the optically selected quasars may not be strong synchrotron sources in any part of the spectrum or they might be radio quiet due to some frequency selective absorption.

Extrinsic – the distribution and size of relativistic beams may preclude frequent detection.