NEWS AND VIEWS

Watershed in X-ray Astronomy

To a certain extent the article on page 96 of this issue of *Nature* from the X-ray astronomy group at the Massachusetts Institute of Technology is a record of disappointments. That is not to say that the data reported there from rocket flights carried out since 1967 have not been valuable—the work by the MIT group on the untangling of the X-ray sources in the direction of the centre of our galaxy is generally regarded as the best of its kind—but it is clear that the group has not achieved what it has been searching for; the identification with visible objects of the X-ray sources near the galactic centre. Now that the first satellite to be devoted to X-ray astronomy has been launched, and is apparently working successfully, the MIT article and another from the same group which is in next Monday's *Nature Physical Science* are in some ways a record of what has been achieved in specific areas by rocket-borne X-ray detectors (for a summary of the second MIT article see page 84 of this issue).

The way that many X-ray sources are concentrated in the constellations Scorpius and Sagittarius, the direction of the galactic centre, has been a problem almost since the days immediately after the discovery of Sco X-1 in 1962 which started X-ray astronomy. That the sources are contained within our galaxy, and are not scattered through intergalactic space like galaxies and quasars, is certain from the way the sources are concentrated in the direction of the galactic centre, which is why they are given the prefix GX for "galactic X-ray source". It is now known that the concentration of sources is unlikely to be in the Sagittarius spiral arm of the galaxy; extrapolating this density of sources to the other arms would lead to an estimate of the total emission of X-rays from the galaxy exceeding that which is observed.

It is disappointing, however, that the boost given to X-ray astronomy by the identification of Sco X-1 with an anomalous object having large ultraviolet excess has petered out as far as the sources near the galactic centre are concerned. Objects as anomalous as the visible counterpart of Sco X-1 are rare, so it might have seemed good enough to fix the positions of the sources to a few minutes of arc and then scan the error rectangle for peculiar objects. Yet this subjective approach has not so far turned up any likely identifications, even when the positional accuracy has been at its best. In September the MIT group reported positions with error circle radii of between 1.2 and 2.6 minutes of arc for four of the Sagittarius sources, using a system known as a rotating modulation collimator, which compares with previous error circle radii from 10 to 20 minutes. Even so, none of the sources could be identified with anything visible (nor could any radio emission be detected, which seems to rule out supernova remnants); the error circles contain a few tens of objects, none of which seem remarkable enough to warrant an identification (*Astrophys. J. Lett.*, **161**, L161, 169 and 173; 1970).

What this seems to mean is either that the sources are not anomalous like Sco X-1, at least not at visible wavelengths, so that positions will have to be accurate to a few seconds of arc rather than minutes before there can be successful identifications, or that the sources are too far away to be visible or are blotted out at visible wavelengths by obscuring matter.

In spite of the failure to identify any of the sources the MIT group has done good work by making the direction of the galactic centre less confusing. The positions which are given in this week's article for eleven distinct sources that have been recognized will be the basis for future work. Following the successful launch of the first Small Astronomy Satellite in December, however, which will revolutionalize X-ray astronomy by breaking astronomers' dependence on brief rocket and balloon flights, the articles from MIT take on the appearance of a swansong. It is clear that X-ray astronomy will never be the same, at least not in the 2 to 20 keV band covered by the satellite and which has been popular among the groups using rockets. One estimate is that the ability to detect objects thirty times fainter than the present limit which the long observing times of the satellite confers will increase the number of known X-ray sources from about forty to several hundred. For reasons like these, X-ray astronomers using rockets have been looking over their shoulders a lot recently, and many have been moving to lower energies —less than 1 keV—which are so far not covered by satellite experiments. At higher energies than those covered by the new satellite, the large detector sizes and long integration times needed mean that balloons are in many ways preferable to rockets in any case. Even so, the rocket work will still stand—now that it is realized that some X-ray sources vary in strength with time, the rocket measurements of the strength of X-ray sources during the sixties will always be valuable.

Yet the satellite X-ray detector, designed by the group at American Science and Engineering, Cambridge, Massachusetts, does not have a sufficiently good resolution to solve the problems of identification raised by the MIT group. This is the purpose behind the proposal for a satellite to fix the positions of sources with a precision of the order of seconds of arc, using lunar occultation techniques, raised by an ESRO Mission Definition Group in *Nature* recently (**228**, 756; 1970). In Britain the fifth satellite in the Ariel series, at present known as UK 5, is earmarked for X-ray astronomy and will probably be ready for launch in mid 1973. Somewhat more sophisticated than the Small Astronomy Satellite it will nevertheless have a similar positional accuracy. The design study was completed last autumn.