population, and conclude that some, and probably all, redshifts are cosmological. Dr L. Woltjer (Columbia University) aptly summarized the attitude of many astrophysicists towards Arp's evidence by saying "it is difficult to believe, but I am still worrying about it".

An independent thread running through the first day was the problem of possible super-relativistic velocities in the radio sources 3C 279 and 3C 120. Dr K. Kellermann (National Radio Astronomy Observatory) pointed out that there are many ways of interpreting the data which do not require "super-*c*" velocities, particularly using models with components in the source blinking on and off; this interpretation was strongly emphasized by Dr W. Dent (University of Massachusetts). Dr I. Shapiro (Massachusetts Institute of Technology) said that, although radio experiments testing general relativity have not yet distinguished between the Einstein theory and the Brans-Dicke theory, radio observations may yet resolve the question.

The second day was devoted to the experimental and theoretical aspects of gravitational radiation. Dr J. Tyson (Bell Laboratories) did not provide supporting evidence for Weber, but emphasized that Weber's work has resulted in so much growth in the technology for detecting gravitational radiation that definitive experiments, whether negative or positive, may soon settle the problem. A "hot" discussion of the subject erupted in the middle of the scheduled programme a couple of days later when Professor J. Weber (University of Maryland) stated an impromptu "theorem" to the effect that there are an infinite number of incorrect ways of conducting experiments for detecting gravitational waves. He suggested that other workers should more closely follow his methods which have been "proven" to produce results. Tyson and others responded rather spiritedly, and on the whole negatively, to Weber's suggestions.

The esoteric theoretical aspects of gravitational radiation were discussed by Dr R. Geroch (University of Chicago), Professor R. Penrose (University of London), and Professor C. Misner (University of Maryland). Their chief topics were, first, the question of whether considerable energy could be extracted from interactions with singularities (black holes), and, second, whether such singularities would be "naked" or "clothed" (that is, special circumstances could allow radiation to escape from inside a singularity).

On the third day Professor F. Pacini (Laboratorio Nazionale di Frascati) and Professor F. Drake (National Astronomy and Ionospheric Center) reported on the state of the theory and observations of pulsars. Although some clarifications have occurred and some observational dogmas discredited, the advance of the subject has not been as great as was once hoped.

The striking impact of X-ray astronomy on relativistic astrophysics was evident in the reports of Dr R. Giacconi and Dr H. Tananbaum (American Science and Engineering). The most exciting subject of the symposium concerned the unusual X-ray, optical, and radio events occurring in close binary stars. Tananbaum's discussion of the X-ray eclipsing system Her X-1, and the report by Professor N. Bahcall (Princeton University) on its probable optical counterpart, HZ Herculis, revealed exceptionally interesting data on a binary system which eclipses in both the optical and the X-ray regions of the spectrum, has both short and long term on-off cycles, shows effects of X-rays heating a probable A star to make it appear much hotter on one side, produces pulses by containing a compact object with a "hot spot" rotating every 1.24 s, and shows a host of other interesting details.

The theoretical aspects of X-ray double stars were discussed by Dr K. Prendergast (Columbia University) and Dr D. Pines (University of Illinois). Professor B. Paczynski (Warsaw Institute of Astronomy) summarized what is known about the evolution of close binaries and gave a warning about well known traps awaiting people who interpret data on close binaries too simply. Dr R. Hjellming (National Radio Astronomy Observatory) discussed the radio phenomena associated with both close binary stars and X-ray stars, emphasizing that unusual high energy phenomena must be associated with both types of objects. The workshop on black holes found several supporters for the "almost invisible" component of Cyg X-1 as the currently known object likely to be a black hole.

Details of the X-ray close binaries (Cen X-3, Her X-1, and Cyg X-1) were discussed by Professor R. Ruffini (Princeton University); in particular he considered whether the compact objects that must be present are black holes or "ordinary" neutron stars. The sense of the discussions was that, because of effects by which a star of lower mass could mimic one of higher mass, it was probably not yet safe to declare that Cyg X-1 contains a black hole. The case for this is, however, improving, and in the near future one may be able to say a black hole has been "observed".

The last day of the symposium consisted of talks by Dr R. Omnes (High Energy Laboratory at Orsay) and Dr S. Frautschi (CalTech) about physics at the origin of time, and several talks on miscellaneous subjects, of which the first reports of X-ray observations with Copernicus presented by Dr P. Sanford (Mullard Space Science Laboratory) and the report by Professor A. Penzias (Bell Laboratory) on the first detection of deuterium in interstellar space were perhaps the most interesting. Penzias reported that deuterium was found in the Orion nebula through detection of radio lines from the molecule DCN; the abundance of deuterium is roughly an order of magnitude greater than expected.

MARINER 1977

Experiments Chosen

EXPERIMENTS planned for the two Mariner missions to Jupiter and Saturn, to be launched in 1977, have been divided into eleven groups, NASA announced recently. The two craft will be identical, although they may follow slightly different trajectories, and will use the gravity field of Jupiter to accelerate them past Saturn; this mission is the remnant of a more ambitious "Grand Tour" plan for one or more spacecraft each to visit all the outer planets by repeated use of this gravitational slingshot effect. That has now been abandoned, even though a suitable alignment of the outer planets occurs only once every 179 yr.

The two missions now proposed will carry instruments for:

- Optical imaging of Jupiter, Saturn, their moons and the rings of Saturn.
- Radiofrequency studies of Saturn's rings, the atmospheres of both planets and of interplanetary space.
- Infrared studies of the planets; this will assist in determinations of atmospheric composition.
- Ultraviolet spectroscopy.
- Magnetometer investigation of the interplanetary magnetic fields as well as those of the two planets.
- A plasma experiment to study the interaction of the solar wind with the planets.
- Analysis of low energy cosmic rays and particles in the radiation belts of the planets.
- Investigation of high energy (interstellar) cosmic rays.
- An experiment to determine velocity and range of interplanetary and interstellar particulate matter.
- Photopolarimetry of the atmospheres of the planets and investigation of reflective properties of their moons and Saturn's rings.
- Studies of the non-thermal radio emission of the planets, their plasma resonances and magnetospheres.

The flight will take four years, covering 807×10^6 mile, and will be planned in detail in the light of the preliminary investigation by Pioneer 10 of deep space and the region near Jupiter.