uate the differential coefficients appearing in the equations of condition. For example:

$$\frac{\partial \theta}{\partial e} = \left\{ \frac{57.3 \sin v (2 + e \cos v)}{1 - e^2} \right\} \{1 - \sin^2 i \cos^2(\theta - \Omega)\} = \alpha \cdot \beta,$$

where v is the true anomaly. Although $\partial \theta / \partial e$ is a function of four parameters, namely, e , v , i , and $(\theta - \Omega)$, it is possible to *tabulate* two functions, α and β , whose product gives $\partial \theta / \partial e$. α is a function of only e and M (the true anomaly) and β is a function of only i and $(\theta - \Omega)$. e , M , i , and $(\theta - \Omega)$ are known at each point so that the evaluation of a single value of $\partial \theta / \partial e$ involves two table lookups and one multiplication—a matter of a minute or less.

The other differential coefficients can be treated in somewhat similar fashion. A total of 11 tables suffices and these tables have been calculated with the IBM 650 at the Indiana University Research Computing Center. In a typical case, the use of these tables enables the computer to calculate and check all necessary coefficients in a matter of a very few hours. The tables can also be used to correct the elements one at a time.

Tables of $\partial X / \partial e$, $\partial Y / \partial e$, $\partial X / \partial M$, and $\partial Y / \partial M$ have also been calculated. Such tables are useful in a least-squares solution involving x and y rather than ρ and θ .

Reliability Approach to Astronomical Satellites.

EDWIN D. KARMIOŁ AND JOHN S. YOUTCHEFF, *General Electric Company, Missile and Space Vehicle Department, Philadelphia, Pennsylvania*.—As in all complex systems, astronomical satellite reliability is essential in the attainment of the operational objectives. However, the uniqueness of astronomical observations in space imposes reliability considerations and requirements which are equally unique. In determining the adequacy of the astronomical satellite to meet these requirements satisfactorily, techniques can be employed to predict the system reliability utilizing methods developed in ballistic missile and space vehicle reliability programs. This paper discusses the astronomical satellite operational and environmental problems and the techniques that can be employed to predict the probability of successful system functioning in the operational environment.

A New 21-cm Interpretation of the Spiral Structure and Motions of the Galaxy. F. J. KERR, *CSIRO Radiophysics Laboratory, Sydney, NSW, Australia*.—A detailed comparison has been made between the Leiden and Sydney 21-cm surveys for the two halves of the Galaxy. The first reduction of the observations was done in a homogeneous manner, using the Leiden rotational velocity model for the whole Galaxy. This yielded a quite implausible

spiral structure diagram, and it was necessary to consider alternative models. As a basic criterion, the assumption was made that the structure and motions of the Galaxy are symmetrical on a large scale.

The observations for the southern side lead to somewhat lower apparent rotational velocities than are observed on the northern side. The results on the two sides of the Galaxy can be reconciled by introducing an additional solar motion component of 7 km/sec in a direction outwards from the galactic center, in other words, an outward motion of the young stars which are mainly involved in the determination of the "local center of rest." (This motion is relative to very distant hydrogen, and so the result is not in conflict with optical results on the solar motion relative to nearer objects.) A further anomaly is found in the asymmetrical appearance of the 21-cm relief map of the galactic disk, when based on the earlier model. This result, together with the lack of relative motion between the local stars and local gas, suggests that the gas at the sun's distance from the center is also moving outwards with a velocity of 5–7 km/sec. This motion is presumably related to the rapid outflow of gas which is known to be occurring in the central region.

A new spiral diagram has been derived, taking both rotation and expansion into account; the arms are more continuous and the general pattern has a more reasonable appearance than in earlier interpretations. Some of the implications of the proposed velocity picture will be discussed.

Star Distribution in the Globular Cluster M15.

IVAN KING, *University of Illinois Observatory*.—Star counts and photoelectric surface photometry have been combined to derive the star distribution in the globular cluster M15, from the small central core to the edge of the cluster. Because of its high central concentration, M15 is a severe test for any empirical law. The core has a radius of ten seconds, while cluster stars are easily detectable 15 minutes from the cluster center.

A plot of the logarithm of projected density against $\log r$ shows clearly that no power law will represent the distribution. Instead it appears that the density approaches zero at a finite value of r , exactly as should be expected for a cluster in the tidal field of the Milky Way. From $r=1'$ out to the limit of the observations, the projected density in M15 is closely proportional to $(1/r - 1/r_0)^2$. Extrapolation gives for the tidal limit of M15 $r_0=21'$, a figure which agrees well with the theoretical estimate. The formula also closely represents the densities outside the central cores in Centauri, 47 Tucanae, and M13, provided suitable values are taken for r_0 .

In the neighborhood of the limit, the above formula goes to zero as $(r_0 - r)^2$. This can be shown to

be a necessary consequence of the relaxation process in the cluster. Also, when r_0 is large this formula becomes the same as Hubble's law for the outer parts of spherical galaxies.

No attempt has yet been made to modify the formula to represent the leveling off of density in the central parts. However, it appears possible to do this by introducing one more parameter, to express the central concentration of the cluster. If this turns out to be so, it will be possible to represent the radial density distributions in all globular clusters by a single formula, and except for scale factors the differences between distributions will be given by a single concentration parameter.

The Dynamics of the Pleiades Cluster. D. NELSON LIMBER, *Yerkes Observatory, Williams Bay, Wisconsin*.—An estimate for the total stellar mass of the Pleiades is obtained through the application of an extended form of the virial theorem that takes account of the intracluster gas and dust. Published observational data have been taken as the sources for the required estimates for the relative spatial distribution of the stars and for the relative spatial distribution and total mass of the intracluster neutral hydrogen. With the results so obtained, the larger problem of the evolution of the cluster is examined in some detail. Conclusions are drawn concerning the luminosity function, the mass-spectrum, and the detailed dynamical state of the cluster.

The Distribution of Local Hydrogen from a 21-cm Multichannel Survey of the Sky. R. X. MCGEE AND J. D. MURRAY, *CSIRO Radiophysics Laboratory, Sydney, Australia*.—The whole sky visible from Murraybank, (lat. $-33^{\circ}75'$), near Sydney, has been observed with a multichannel 21-cm hydrogen-line receiver and a widebeam aerial ($2^{\circ}2'$ between half-power points). From sample reductions of H -line profiles the disposition of local neutral hydrogen is presented in terms of three schematic diagrams: The distribution in N_H , the number of hydrogen atoms in a line-of-sight column of 1 cm^2 section, a diagram of representative line half-widths and the observed distribution of profile peak radial velocities.

Indications have been found that the gas has a general horizontal stratification in which regions of excess density occur. Its arrangement in space does not appear to be correlated with the so-called Local System but may have some connection with the local galactic magnetic field. Assuming the form of the distribution with z given by Schmidt, half-thickness 220 parsecs, an estimate of the density near the sun is $1.0 \text{ H atoms cm}^{-3}$.

The line profiles away from the Milky Way were generally single peaked with a range 12 to 35 km/sec

in half-width. Wide profiles of half-widths 36 to 140 km/sec were consistently observed in large regions near the galactic poles. Large-scale grouping of profiles in the comparatively narrow range 12–20 km/sec occurred corresponding closely with the outstanding features of the N_H distribution. This fact pointed to the compact nature of such large local complexes as the Scorpius-Ophiuchus spur and the Taurus-Orion region.

The Latest Cycle of the Be Shell Star β Mon. DEAN B. McLAUGHLIN, *University of Michigan, Ann Arbor, Michigan*.—This star is one of the brightest actively changing Be shell stars. Variation of V/R type is conspicuous, with a period of about 12.5 years. The hydrogen-emission lines, about 5 Å wide, oscillate in the same direction and with practically the same amplitude as the central absorption lines. As in other V/R variables, greatest positive velocity occurs when the violet emission component is strongest.

In previous cycles (McLaughlin, D. B., *Astron. J.* 56, 44, 1951) the velocity range was from about +5 to +45 km/sec. During the latest cycle the amplitude was greater, the maximum being +60 km/sec. Throughout much of the rising branch of the curve, from 1952 to 1956, the shell absorption was greatly weakened, repeating the behavior in the previous cycle. Velocities of the absorption lines became systematically discordant. The first line to shift positively was $H\delta$ early in 1954. In 1955 $H\gamma$ followed, but $H\beta$ lagged and the lines remained discordant until late in 1956, when they had recovered much of their usual great strength.

The K line of Ca II showed unusual behavior. From 1930 to 1952 it was evidently wholly interstellar, with velocity +20 km/sec. From early 1953 to 1955 its velocity appeared definitely higher, averaging +35 km/sec. Throughout 1956 and 1957 a conspicuous additional K line appeared with velocity +100 to +130 km/sec. Simultaneously $H\delta$, $H\epsilon$, and $H\zeta$ developed weak absorption components with similar velocities, while the strong main hydrogen absorptions were at about +60 km/sec. During 1958 these extra hydrogen lines were not seen, and the K line shifted toward accordance with the main hydrogen components. In 1959 and 1960 the K line was accordant with hydrogen near +50 km/sec.

The Radio Telescope of the University of Illinois. G. C. McVITTIE, *University of Illinois Observatory*.—The telescope is a transit instrument with a reflector fixed to the ground; it has been designed by George W. Swenson, Jr., and its construction is being financed by the Office of Naval Research. The reflector is a parabolic cylinder whose dimensions are 600 by 400 ft, the longer dimension running