DIVISION ON DYNAMICAL ASTRONOMY

Propulsion Laboratory - The symplectic property of the state transition matrix is very often used as an accuracy check of the numerical solution to the variational equation of a dynamical system. Because of the way in which it is usually applied, the test tends to be overly pessimistic. This paper discusses the problem in general and presents an algorithm for more reliable accuracy estimates.

A Dynamical Model With A "3 kpc Arm." W. L. PETERS, U. of Texas, W. W. ROBERTS, JR., U. of Virginia - A dynamical model based on the concepts of the density wave and galactic shock wave has been considered for the bar structure in barred spiral galaxies (1971, W. W. Roberts, Jr., A.A.S. Meeting, Amherst). Possible application of this dynamical model to the inner regions of our own Galaxy is investigated here. The model galaxy considered is a thin disk consisting of gaseous and stellar components whose base state of motion is a circular motion about the galactic center in the plane of the disk. Superimposed on this disk is a stellar density wave which, together with the gaseous response, represents a bar structure in the inner regions of our own Galaxy. The results show that such a gas flow will produce a so-called "3 kpc arm" for one orientation of the bar with respect to the sun. The fit is promising in view of the fact that the orientation was the only parameter adjusted to achieve the fit, the other parameters being fixed by prior considerations.

The Gas Content of Galaxies. William J. Quirk, Hale Observatories, Carnegie Institution of Washington, California Institute of Technology. The following hypothesis is suggested: "If the gas in a galaxy is Jeans unstable, efficient star formation results." One consequence of this hypothesis is that if the gas density of a galaxy is large enough to be Jeans unstable, star formation will deplete the gas until it is just barely Jeans unstable. Provided one knows the rotation curve for a galaxy, it should be possible to use the Goldreich and Lynden Bell criterion to predict the peak density of gas as a function of radius, assuming there are no other efficient mechanisms for star formation.

An attempt is made to compare the densities calculated in this way with the densities observed in external galaxies. The hypothesis is found to predict the decrease in gas content and stabilization in the outer half of most galaxies, but to overestimate the densities in the inner half of the galaxies; this may be due to some very efficient star formation process which becomes important when the average gas density reaches a certain limit.

The above hypothesis may explain the rough correlation between Hubble type and gas content. It predicts that the galaxies, which according to the Lin-Shu dispersion relation should have tight arms, should also have a low percentage of their mass in gas.

Shock Formation Along The Perseus Spiral Arm, And Related Dynamical Phenomena. W. W. ROBERTS, JR., University of Virginia. A dynamical model based on the density wave and shock wave concepts is considered for the Perseus arm. In this model, which represents an extension of the two-armed spiral shock model for the large-scale motion of the interstellar gas in the outer parts of the galactic disk, the Perseus arm is visualized to consist of a galactic shock wave embedded in a background density wave. The large-scale systematic motion observed along the Perseus arm can be accounted for as the systematic motion predicted in the model. Splitting of an N I feature into multiple subcomponents of the type found in observed profiles of neutral hydrogen arises rather naturally in the presence of a galactic shock. The interstellar absorption line complexes which are seen in front of large O-associations and which have considerably larger negative velocities than the associations themselves and thus according to the equilibrium Schmidt model of rotation should refer to material behind these associations, also find a rather natural interpretation with a shock wave present. Secondary arms are found to arise in the model over the region outside the solar circle, and these bear some resemblance to the secondary arms, "spurs," and "feathers" which are often observed in the outer parts of external spiral galaxies and our own Milky Way System.

Evidence for Density Wave Streaming in Three Spiral Galaxies. D.H. RODSTAD and G.S. SHOSTAK, Owens Valley Radio Observatory, California Institute of Technology. Aperture synthesis studies of the neutral hydrogen in several spiral galaxies have yielded moderate resolution maps of their velocity fields. In the galaxies NGC 2403, M101 and NGC 6946 we find significant deviations from circular rotation. These peculiar velocities, typically on the order of 10 km/s, tend to be systematic along arms coinciding with optical spiral arms, and are in qualitative agreement with the streaming motions predicted by the density wave theory of spiral structure.

Clusters of Galaxies and the n-body problem. D.G. SAARI, Northwestern University. Clusters of galaxies are studied using the qualitative behavior of solutions of the n-body problem. (Saari, 1971 Astrophys. J. 165, 399-407). It follows from this work that it is not surprising that galaxies are divided into clusters. In one classification of clusters the behavior of the velocities is such that it would be difficult to observationally determine whether the system is bounded or disintegrating. This may be a partial answer to the question of whether the "Virial Theorem" is measuring "hidden mass." Furthermore the centers of mass of the galaxies tend toward well-defined configurations. These configurations depend on the masses and in some cases could be used to determine the completeness of a cluster or to determine the individual masses of the galaxies up to proportionality parameters. Clusters satisfy a (functional) "Hubble's constant" where the "constant" has two distinct values. Finally there is a motion called oscillatory where in general some of the velocities would be too large to satisfy a Hubble's relationship. However I doubt if the velocities would be large enough to explain quasars via dynamics (nor would it explain the absence of blue shifts). From the dynamics one would expect this motion to be separated from clusters of galaxies. This seems to be true for quasars as reported by Arp (1971, Science 174, 1189-1200).