Generalized Lin-Shu Theory of Density Waves

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The gravitationally unstable stellar disk of galaxies is considered using a gas-dynamical approach. The model differs from the previous work in the inclusion of destabilizing effects resulting from shear, azimuthal force and spatial inhomogeneity, and a stabilizing effect resulting from finite thickness of the galaxy. A plasma physics method is given for the analytical solution of the self-consistent system of the gas-dynamical equations and the Poisson equation describing the stability of the disk when the system is perturbed in an arbitrary manner. That is, when a gravity perturbation (e.g. that produced by a spontaneous disturbance) does not distort the disk's equatorial plane and when it does distort the disk's plane. As an application of the method, the modifications introduced for the properties of the Lin-Shu type compression waves, or density waves, studied in connection with the problem of spiral structure of galaxies, are considered by removing the oftenly used assumptions that the perturbations are axisymmetric and the disk is infinitesimally thin. The extent to which our results on the disk's stability can have a bearing on observable spiral galaxies is discussed as well.