Resonant Excitation of Spiral Density Waves in Galactic Disks

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Linear kinetic theory is developed to describe the resonant Landau-type excitation of spiral density waves in a self-gravitating, rapidly and nonuniformly rotating, spatially inhomogeneous, and practically collisionless stellar disk of flat galaxies. The system is treated by employing the well elaborated mathematical formalisms from plasma perturbation theory using normal-mode kinetic analysis. It is shown that the kinetic wave–star interaction at the corotation resonance in a hydrodynamically stable nonuniformly rotating disk of particles resembles a Cherenkov emission of electromagnetic waves (light) with continuous spectrum and specific angular distribution by an electric charge moving in a medium at a constant velocity. This Landau excitation of spiral density waves is suggested as a mechanism for the formation of observable structural features such as spiral arms, and the slow on a Hubble time dynamical relaxation of disk-shaped galaxies, in a parameter regime of classical "hydrodynamical" Jeans stability. A separate investigation based on extensive parallel N-body computer simulations is described to determine experimentally these Landau-growing, oscillatory propagating collective modes of oscillations.