High-Current Plasma Electron Sources

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In this report we present the design, electrical schemes and preliminary results of a test of 4 different electron plasma cathodes operating under high-voltage pulses in a vacuum diode. The first plasma cathode consists of 6 azimuthally symmetrically distributed arc guns and a hollow anode having an output window covered by a metal grid. Plasma formation is initiated by a surface discharge over a ceramic washer placed between a W-made cathode and an intermediate electrode. Further plasma expansion leads to a redistribution of the discharge between the W-cathode and the hollow anode. An accelerating pulse applied between the output anode grid and the collector extracts electrons from this plasma. The operation of another plasma cathode design is based on Penning discharge for preliminary plasma formation. The main glow discharge occurs between an intermediate electrode of the Penning gun and the hollow anode. To keep the background pressure in the accelerating gap at $P \leq 2.5\times10^{-4}$ Torr either differential pumping or a pulsed gas puff valve were used. The operation of the latter electron plasma source is based on a hollow cathode discharge. To achieve a sharp pressure gradient between the cathode cavity and the accelerating gap a pulsed gas puff valve was used. A specially designed ferroelectric plasma cathode initiated plasma formation inside the hollow cathode. This type of the hollow cathode discharge ignition allowed to achieve a discharge current of 1.2 kA at a background pressure of 2×10^{-4} Torr. All these cathodes were developed and initially tested inside a planar diode with a background pressure $\leq 2\times10^{-4}$ Torr under the same conditions: accelerating voltage 180 – 300 kV, pulse duration 200 – 400 ns, electron beam current ~ 1 – 1.5 kA, and cross-sectional area of the extracted electron beam 113 cm^2.

Plasma-Like Collective Instabilities in Stellar Disks of Galaxies

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There is a formal analogy between the collective oscillations in a rotating stellar disk of spiral galaxies and the oscillations of a hot collisionless plasma in a magnetic field [1,2]. The collisionless Boltzmann equation governing the evolution of a stellar disk resembles the Vlasov equation for a plasma; thus, the technique of plasma kinetic theory may be applied. The conception of unstable oscillations already played a remarkable role in understanding of many processes occurring in galaxies such as the spiral structure [3-4].

We treat a disk of stars by employing the well elaborated mathematical formalisms from plasma perturbation theory using normal-model analysis [5-8]. Although both plasmas and gravitating disks are collective systems, in fact plasmas are significantly different from galactic disks (the sign of interaction, etc.). A principal difference between plasmas and gravitating systems is that the latter ones because of the nature of the gravitation force, are *always spatially inhomogeneous. This point is essential: quasi-stationary gravitational disks* must be essentially nonuniform. We include the effects of disk inhomogeneity, i.e., the effects of surface density, angular velocity, and random velocity dispersion (square root of ``temperature") spatial gradients in the study of disk's instabilities.

To describe the ordered behavior of a medium near its quasi-equilibrium state a general dispersion relation that connects the frequency of excited oscillations with the wavenumber throughout the disk is obtained. Using the dispersion relation, a gravitational Jeans-type instability is discussed. In plasma physics an instability of the Jeans type is known as the negative-mass instability of a relativistic charged particle ring or the diocotron instability of a nonrelativistic ring that caused azimuthal clumping of beams in synchrotrons, betatrons, and mirror machines. We show that the Jeans instability of gravity disturbances is one of the most frequent and most important instabilities in the galactic dynamics.

Similar to bunching instabilities in plasmas, e.g., pinch instabilities or a firehose instability, the instability is driven by a strong interaction of the gravity fluctuations with the bulk of the particle population, and the dynamics of Jeans perturbations can be characterized as a fluidlike interaction. The almost aperiodic Jeans instability does not depend on the behavior of the particle distribution function in the neighborhood of a particular speed, but the determining factors of the instability are macroscopic parameters like the random velocity spread, mean density, and angular velocity of regular rotation. The Jeans instability associated with departures of macroscopic quantities from the thermodynamic equilibrium is hydrodynamical in nature and has nothing to do with any explicit resonant effects. The instability is due to the nature of the galactic system: the free kinetic energy associated with the rotation and the gravitational potential energy are possible sources for the growth of the average wave energy.

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