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Excitation of dust acoustic modes in dusty plasmas of Saturn's rings

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We have studied the effect of dissipative forces on the propagation of the low-frequency density waves in the dusty plasma of planetary rings. It turns out that the collisional effects estimated for the region of the main Saturn's rings (our estimations are based on the local observations of the Cassini spacecraft in the vicinity of the main A and B rings) may be large enough to affect the low-frequency dust-acoustic mode. In particular, we have demonstrated that the ion drag force related to the momentum transfer from the moving ions to the charged dust can be an important factor affecting the mode stability of the low-frequency electrostatic perturbations. Two features determine the exceptional role of the ion drag force in the dusty plasma of the main rings - the occurrence of a ring atmosphere/ionosphere and of a relative motion between the plasma and dust particles. The relative velocity causes the existence of radial zones of transparency for the dust-density wave propagation and regions where the dust-plasma waves are damped. We found that inside the co-rotation distance (where the plasma ions move slower than the dust grains) the ion drag force can be responsible for the excitation of dust-acoustic perturbations due to the dissipative instability. The source of free energy for this instability comes from the azimuthal drift of the dusty plasma components. According to our model, the growth rate of this dissipative instability is strongly dependent on the radial distance from the planet. The neutral gas damping (associated with dust-neutral momentum transfer) can quench the instability and move the boundary for the onset of the dust-density mode instability inside the co-rotation distance. The theory also predicts that the smaller the charged particles are, the larger the growth rate of the dissipative instability and the smaller the distance from the synchronous orbit for the onset of this instability. Estimations of the plasma parameters made on the basis of Cassini data, allow us to suggest that the boundary for the onset of the dissipative instability is located in the direct vicinity of the synchronize orbit. Outside the co-rotation distance (where the plasma ions overtake the dust grains) the collisional processes lead to the damped perturbations, and thus the dust-density waves can hardy be excited at this part of Saturn's rings. It is therefore possible that due to the indicated specific features the discovered instability could be of importance for the formation and evolution of Saturn's "spokes" observed by Voyager in the vicinity of the synchronous orbit.