Mode-coupling instability in 2D complex plasma crystals: The role of damping rate

V. Nosenko[1,2], J. K. Meyer[1], S. K. Zhdanov[1], H. M. Thomas[1], J. Carmona-Reyes[2], and T. W. Hyde[2]

[1]Institut für Materialphysik im Weltraum, Deutsches Zentrum für Luft- und Raumfahrt (DLR), 82234 Weßling, Germany
[2]Center for Astrophysics, Space Physics, and Engineering Research, Baylor University, Waco, Texas 76798-7310, USA

Complex, or dusty plasma is a regular plasma where small particles of solid mater are dispersed. Dust particles collect electrons and ions from the plasma, become charged, and interact with each other via a screened Coulomb (Yukawa) potential. As a result, complex plasmas are often strongly coupled and can be in a liquid form or even crystallize. Since dust particles are relatively massive and individually observable, many processes in complex plasmas can be studied in real time at the level of individual particles. An interesting phenomenon which occurs in two-dimensional (2D) complex plasma crystals and lends itself to direct experimental observation and theoretical analysis is the mode-coupling instability (MCI) [1]. It occurs when the dispersion relations of the two dust-lattice wave modes, longitudinal in-plane (L) mode and transverse vertical (TV) mode intersect. In the vicinity of their intersection, a new hybrid mode appears which is unstable. If not suppressed by the neutral gas friction, it will grow exponentially with time and can result in the crystal melting. Therefore, the gas damping rate is very important for the development of MCI. In this contribution, we will present our recent experiments performed across a wide range of the neutral gas damping rates. Here, the damping rate ν_E is normalized by the frequency scale of 2D plasma crystals ω_0 [1].

In experiments with low damping rate, $\nu_E/\omega_0=0.01$, the coupling of the L and TV wave modes was observed even in the absence of their crossing; in fact, the modes were separated by a gap 4 Hz wide [2]. The coupling manifested itself in the traces of the TV mode appearing in the measured longitudinal spectra, i.e., *mixed polarization*. This observation was facilitated, besides low damping, by relatively large particle charges and respective plasma wake charges in these experiments.

In contrast, in experiments with high damping rate, $\nu_E/\omega_0=0.48$, MCI was observed when the deep crossing of the L and TV modes occurred, resulting in the high growth rate of the hybrid mode which was necessary to overcome strong gas damping [3].

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