An Explanation for Physical Mechanism of the Streaming Instability in Dust Dominant Regime

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Streaming Instability (SI) is one of the promising paths against difficulties in planetesimal formation. Recently, numerical simulations have confirmed that in the nonlinear stage, SI generates a local high solid concentration followed by a gravitational collapse that may lead to the planetesimal formation. Its physical mechanism in the linear stage has also been discussed in some papers. However, these previous works cannot fully capture the physical features of SI such as the vertical advection and the dependence on the density ratio between dust and gas. In this work, we show a new physical understanding of SI that explains them.

Based on the equilibrium drift speeds of dust particles given by Nakagawa *et al*. (1986), we derive the dust mass flux in *x*-*z*plane with only the density perturbation and show the interpretation of the phase speed in SI. We use the terminal velocity approximation and solve the dispersion relation to see the motion and the concentration of dust and gas in both dust-dominant and gas dominant regimes. It is revealed that in the gas dominant regime, the dust vertical advection enhances the density maxima, while the dust radial advection weakens it. In the dust dominant regime, these features are opposite. We show an explanation for the physical mechanism in both the regimes.

Keywords: protoplanetary disk, planetesimal formation, instability

