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Gas velocity field around a vortex and the evolution of dust surface density distribution in a vortex

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Planetesimal formation in a vortex is one of the scenarios of planetesimal formation. We investigated the dust accumulation rate in a vortex by solving the equations of dust motion around a vortex semi-analytically. As the result, we obtained that dust surface density distribution in a vortex is independent of not only dust size but also the parameters of a vortex flow and increases in reverse proportion to the square of the length of the minor-axis of concentric ellipses. The parameters of vortex flow are the aspect ratio of vortex ellipse and angular velocity of vortex flow. By the result, mm-sized or bigger dust surface density in a vortex could increase to about 20 times in a vortex. And then, it is suggested that planetesimal formation by the self-gravitational instability would occur.

In this presentation, we evaluate how general is our above result by comparing our local analytical result with our global numerical simulation result. This numerical simulation based on Inaba & Barge 2006$*$ is using two-phase fluid of gas and dust and is simulating vortices formation and dust accumulation in the vortices. Our comparison targets are gas flow field around a vortex and the evolution of dust surface density distribution.

About gas flow field around a vortex, we adopt the analytical flow also used in Johansen et al. 2004$**$ for inside a vortex and modeled analytically by adding the stream functions of a vortex and a back ground Keplerian shear for outside a vortex. For inside a vortex flow, we checked that analytical flow corresponds with numerical flow. For outside a vortex, we also compare our analytical model with numerical result and discuss the difference.

About the evolution of dust surface density distribution, dust is accumulated in a vortex faster in analytical result than numerical result if numerical situation is closed to analytical situation by ignoring the back-reaction of dust motion to the gas flow and using the fixed gas friction coefficient and ignoring the back-ground gas pressure gradient. We discuss about the reason of this difference. We also compare the results in the situation that not ignoring the back-reaction or/and using the not fixed gas friction coefficient or/and not ignoring the back-ground gas pressure gradient. We also evaluate those effects to dust accumulation quantitatively.

$*$Inaba, S. & Barge, P. 2006, ApJ 649, 415
$**$ Johansen, A. et al. 2004, A&A, 417, 361

Keywords: planetesimal formation, vortex, analytical solution, numerical simulation