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Growth of massive black holes in dusty clouds: impacts of relative velocity between dust and gas

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Recent observations have suggested the existence of a large amount of dust around supermassive black holes (SMBHs) in the early universe (e.g. Maiolino et al. 2004). In dusty clouds, the growth of black holes can be significantly regulated due to strong radiation force on dust grains. Yajima et al. (2017) recently showed that the accretion on to intermediate-mass black holes (IMBHs) in dusty clouds are significantly suppressed compared with dustless clouds because of the strong radiation force on dust grains. They, however, assumed that the dust and gas are completely coupled. This assumption might be invalid in the vicinity of black holes. The relative velocity between dust and gas is likely to have impacts on the accretion rate.

We here investigate the impacts of the relative motions of dust and gas on the accretion rate onto IMBHs with the mass of $10^5\ M_\odot$ by using one-dimensional radiation hydrodynamic simulations in clouds with initial gas densities of $n_{\rm H} = 10$ and 100 cm^{-3}. To investigate the effect of grain size on the gas accretion, we introduce two additional fluid components which describe large (0.1 micron) and small (0.01 micron) dust grains in the simulations as we did in Ishiki et al. (2018).

We show that the accretion rate is reduced due to the radiation force. We show that the dust-to-gas mass ratio significantly changes in H$_{\rm II}$ regions because of the relative motions of dust and gas. The decoupling of dust from gas alleviates the suppression of black hole growth compared with the complete coupling case. This effect may allow moderate growth of black holes even in dusty clouds.

Consider for a poster?

Yes

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