FEEDBACK-LIMITED VARIABLE ACCRETION ON TO PLANETS

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Accretion on to giant planets triggers a feedback process, which increases its variability. Feedback variability appears as broadband noise, which can be distinguished from eccentricity-induced variability. The heating of the gap may reduce dust concentration.

Protoplanetary discs, and their interaction with forming planets, are typically modelled using hydrodynamical simulations. These models were originally developed with a local isothermal approximation, meaning that the temperature is prescribed as a fixed function of distance from the central star.

Many observed discs show hot spots, which are likely due to giant planets growing within them. The giant planet accretes gas from its surroundings. This results in an accretion luminosity from the planet. The liberated energy heats the surrounding gas and alters its dynamics. In these cases, the locally-isothermal approximation does not hold.

Montesinos et al. (2015) modified the 2D hydrodynamics code FARGO-AD (Baruteau & Masset 2008) implementing a term that accounts for the heating around a growing planet. In that early work the planet luminosity was a free parameter. Using a value of $10^{-4} L_\odot$, Montesinos et al. (2015) found that the surroundings get temperatures $\sim 300\,\mathrm{K}$, which produces a thermal emission in L' of the order of a millijansky, comparable to observed hot spots.

The planet luminosity however does not need to be a free parameter. Instead, it should be set by the accretion on to the planet, in a *feedback* process. Gárate et al. (2021) implemented this in the code, making the planet luminosity proportional to its accretion rate. The higher temperature close to the planet produces a larger pressure gradient, which reduces the density at that location, and therefore the accretion rate. However, we found that the feedback still allows up to $10^{-3} L_\odot$ planet luminosities, without halting accretion. The process also creates vortices, which propagate and make the accretion rate more variable.

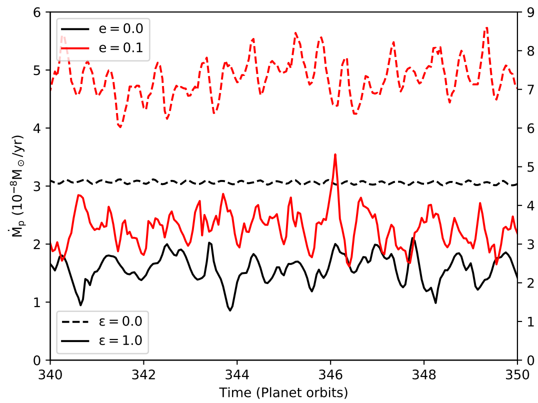

Fig. 1. Accretion rate curves for models with and without feedback implemented ($\varepsilon = 1$ and 0), for different orbital eccentricities ($e = 0$ and 0.1) (Gárate et al. 2021).

Figure 1 shows that the amplitude of the accretion rate variability is similar to that of a planet in an eccentric orbit. However, the models with feedback seem more stochastic. We quantified this by calculating the accretion power spectra (Arévalo et al. 2012), which confirms that accretion induces a higher broadband noise, compared to the well-defined periodic peaks produced by an eccentric orbit.

Finally, we notice that feedback increases the gas pressure inside the gap carved by the giant planet, decreasing the pressure gradient at its edges. This results in a velocity profile for the gas which is closer to Keplerian. This may have consequences for the dust, which will suffer a slower drift and perhaps reduce its accumulation at the outer edge of the gap. We plan to quantify this process in a follow-up work.

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