



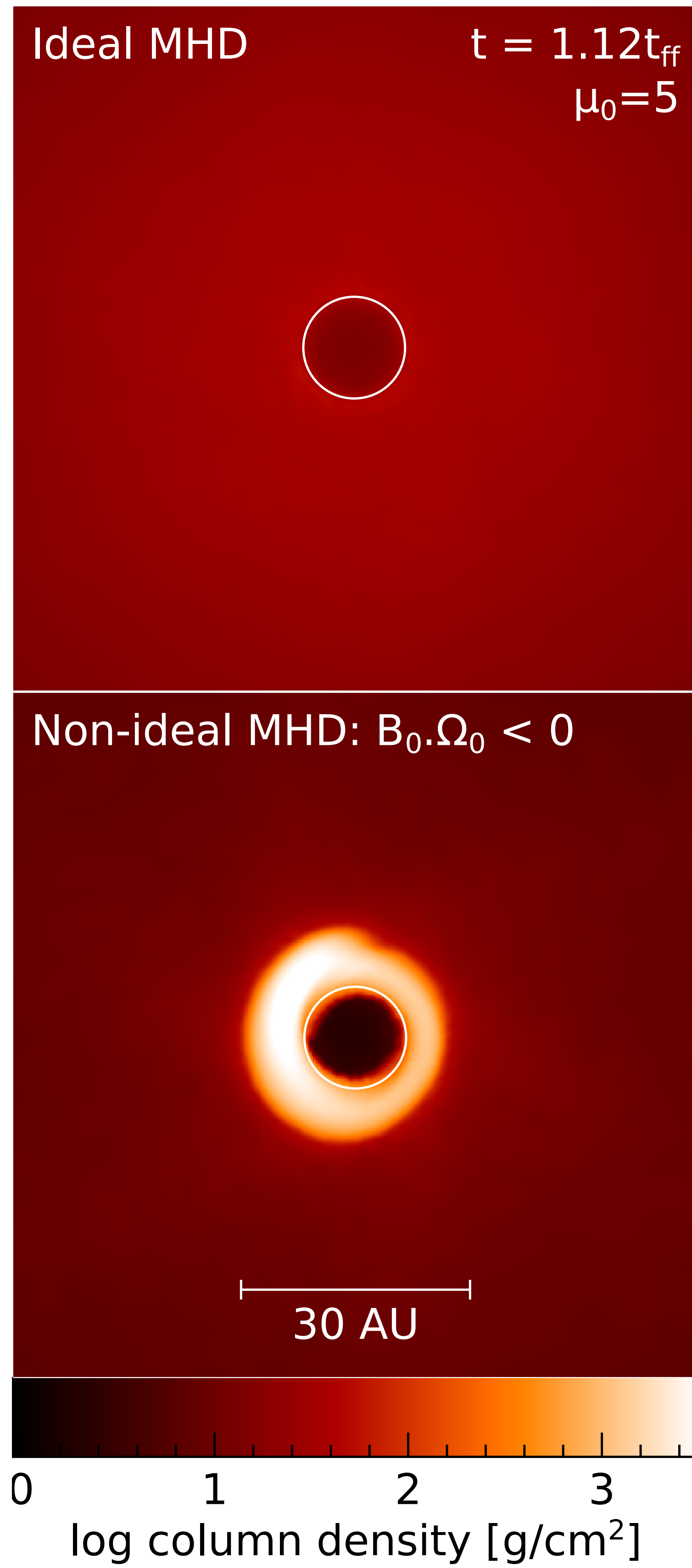
Isolated vs Binary Protostars: The importance of non-ideal MHD

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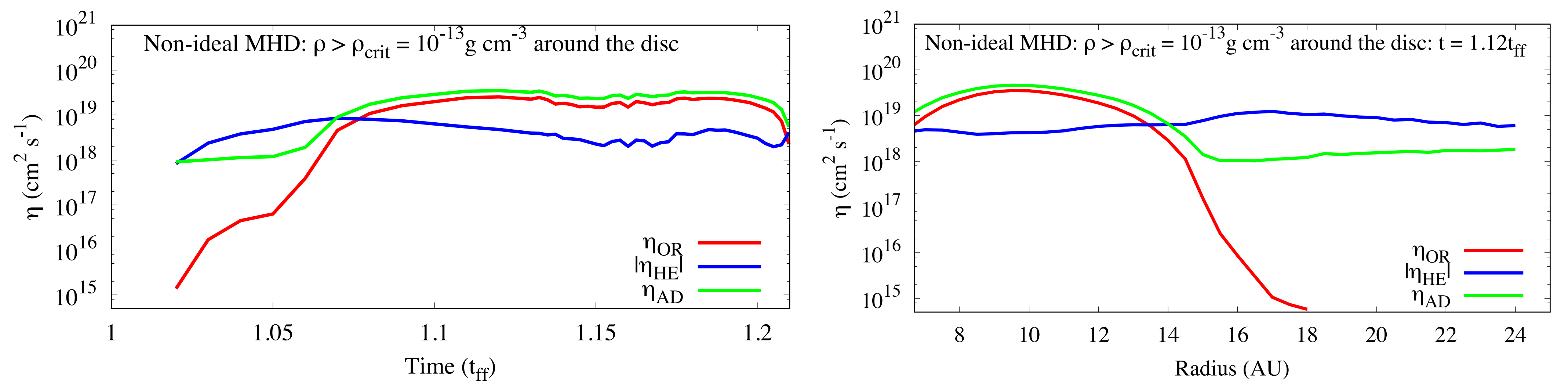
Isolated protostar formation:

Numerical simulations cannot form discs in the presence of strong, ideal magnetic fields, given idealised initial conditions. This is the magnetic braking catastrophe.

We model the collapse of a rotating $1M_{\text{sun}}$ gas cloud of radius 4×10^{16} cm, which is threaded with a magnetic field that is anti-aligned to the rotation axis. The initial rotation, sound speed and mass-to-flux ratio (i.e. magnetic field strength) are $\Omega_0 = 1.77 \times 10^{-13}$ rad s^{-1} , $c_{s,0} = 2.19 \times 10^4$ cm s^{-1} , and 5 times critical.

No disc forms when using ideal MHD. When non-ideal MHD is included, a ~ 15 AU disc forms. The Hall effect is dependent on the direction of the magnetic field with respect to the rotation vector, and its coefficient, η_{HE} , is ~ 1.5 orders of magnitude lower than the ambipolar diffusion coefficient, η_{AD} , in the middle of the disc at $t = 1.12t_{\text{ff}}$. Although weaker, it is strong enough that no disc forms if the initial magnetic field is aligned with the rotation axis.

In summary, non-ideal MHD is important during the formation of isolated protostars.



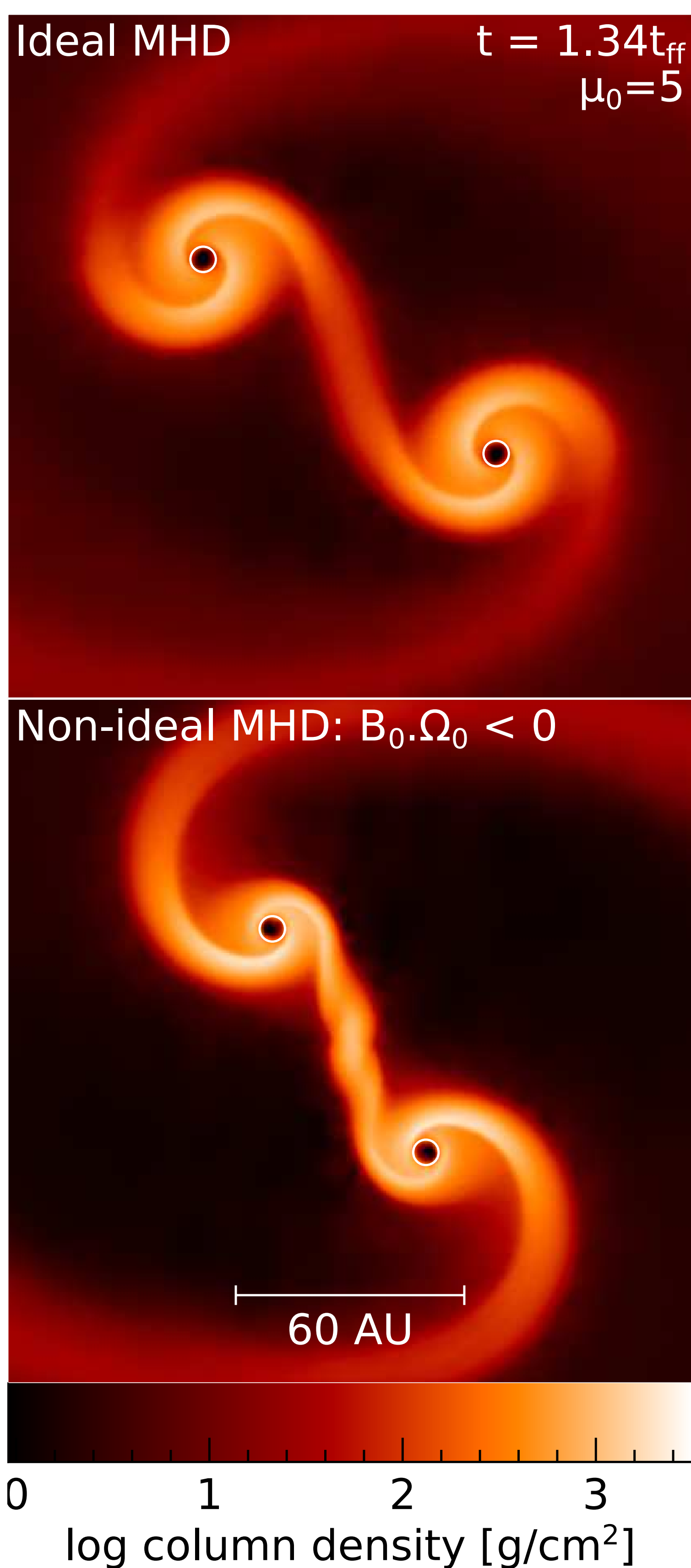
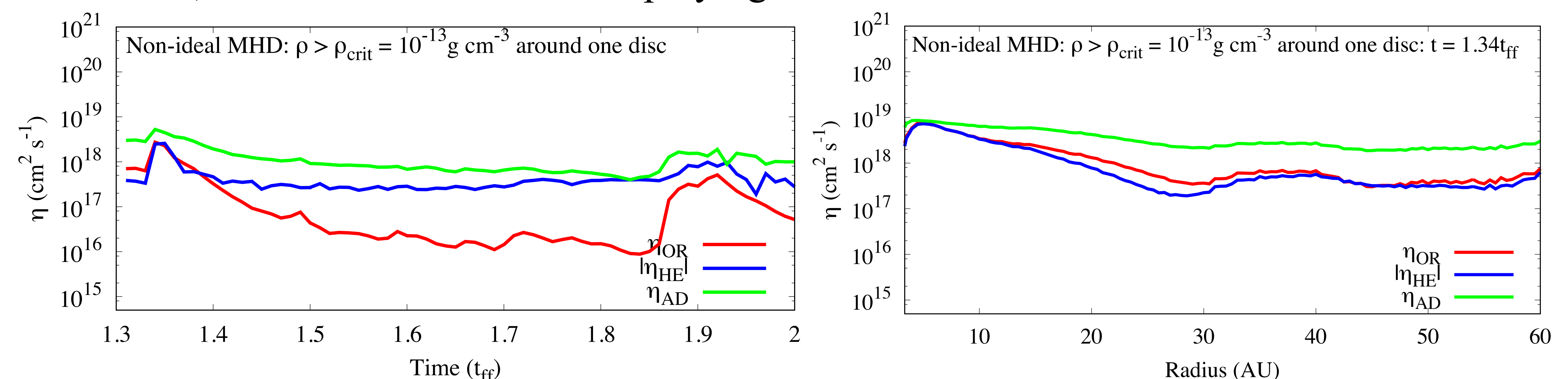
Binary protostar formation:

Discs form ubiquitously in our numerical simulations of wide binary formation, even in the presence of strong, ideal magnetic fields and idealised initial conditions.

We model the collapse of a magnetised, perturbed rotating $1M_{\text{sun}}$ gas cloud of radius 4×10^{16} cm. The initial rotation, sound speed, mass-to-flux ratio, and perturbation are $\Omega_0 = 1.006 \times 10^{-12}$ rad s^{-1} ($5.7 \times$ larger than the isolated models), $c_{s,0} = 1.87 \times 10^4$ cm s^{-1} , 5 times critical, and an $m = 2$ perturbation with an amplitude of $A_0 = 0.1$.

First periastron is smaller and first apoastron is larger in the non-ideal model compared to the ideal model. Compared to the isolated protostars, these non-ideal discs have magnetic fields ~ 10 times weaker, a value of plasma β that is ~ 10 times higher, and non-ideal coefficients that are 1-2 orders of magnitude lower. Thus, the non-ideal effects are weaker in these binary models than in isolated protostar models.

In summary, non-ideal effects cause small differences in the evolution, which may then be amplified by the binary interactions. Thus, non-ideal MHD has only a small effect on binary formation, with the initial conditions playing the dominant role.



References:

Braiding & Wardle (2012): The Hall effect in accretion flows

Wurster, Price & Bate (2016): Can non-ideal magnetohydrodynamics prevent the magnetic braking catastrophe?

Wurster, Price & Bate (in prep): The impact of non-ideal magnetohydrodynamics on binary star formation