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Star formation simulations: caveats

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Abstract. Star formation is such a huge problem, covering such a large range of physical scales and involving so many physical processes, that the results of simulations should always be taken with care.

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Star formation covers such a huge range of physical scales and a wide variety of physical processes – all of which are important – that it is probably the single most difficult problem to address in astrophysics.

Star formation is a complex and chaotic process involving, to varying and uncertain degrees of importance, turbulence, magnetic fields (in particular non-ideal MHD), and feedback (mechanical and radiative, positive and negative). In addition, chemistry and radiative transfer play important roles in determining the thermodynamic properties of the gas (which in turn controls the collapse and fragmentation of the gas into multiple systems and clusters).

The range of physical scales required to understand star formation ranges from kpc or galactic scales (on which feedback-driven turbulence dominates?), to sub-au or Jupiter-mass scales (where gravity and magnetic fields are most important?). No simulation now, or in the foreseeable future can possibly cover the realistic formation of massive GMC complexes in galaxies and also the collapse and fragmentation on sub-au scales to stellar densities.

We have the further problem that what simulations tend to produce is not what observers actually observe. A particular problem is that observations do not directly observe the bulk of the gas in H_2 or He, but tracers such as dust or particular molecules (whose abundance varies with local conditions).

For good recent reviews of star formation theory I suggest McKee & Ostriker (2007), Klessen *et al.* (2009), as well as many chapters in 'Protostars & Planets V' (2007).

Current simulations can only probe a tiny fraction of this parameter space and so their results should always be taken with care. If simulations do not fit observations it does not mean that they are wrong, but if they do fit observations they could still be wrong.

References

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