Radiative feedback from star clusters in giant molecular clouds

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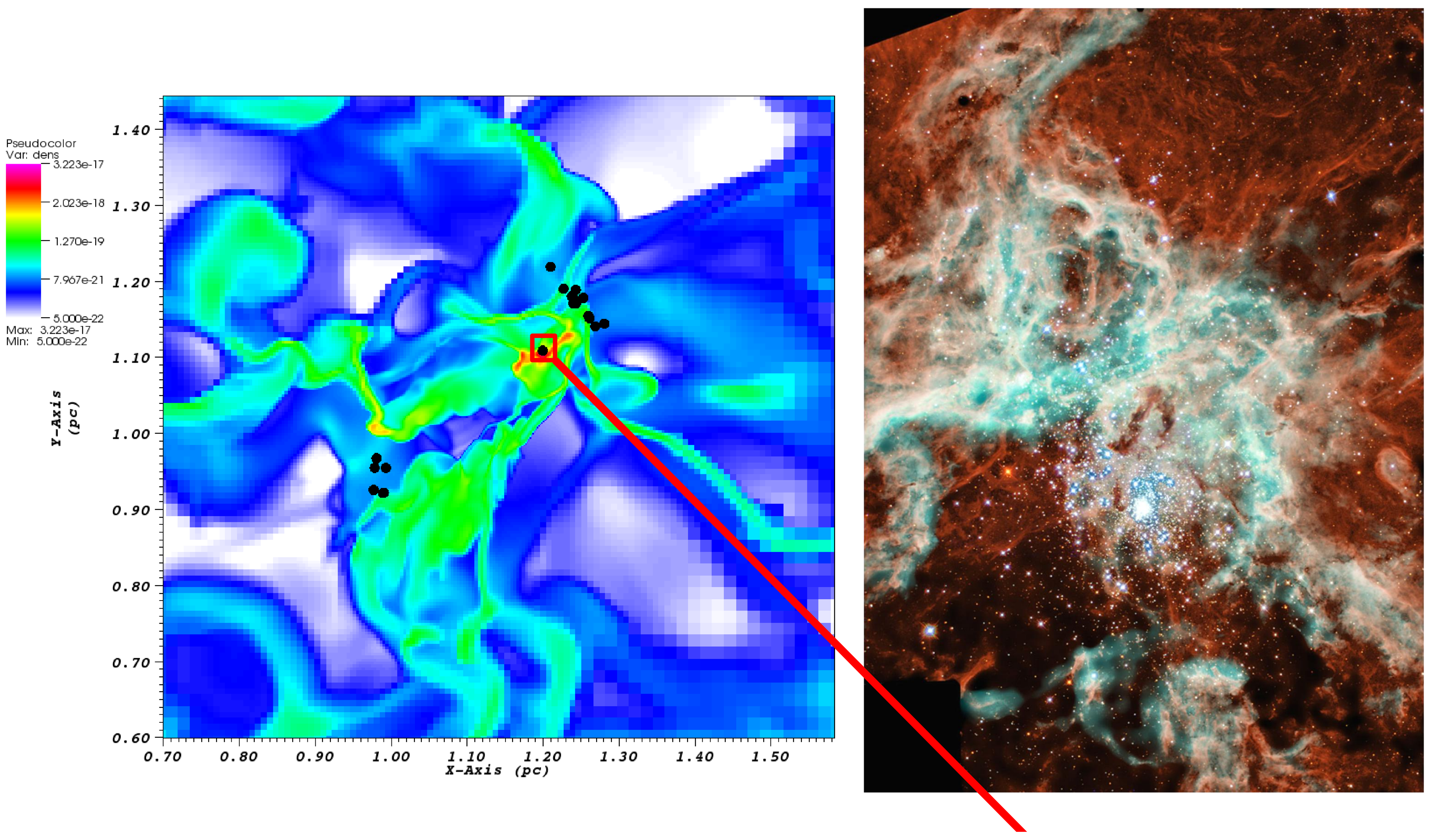

FIGURE 1 Left: A 2D density slice of a FLASH simulation in the process of forming clusters represented by the black dots. Right: An example of a cluster forming region (R136) which we are attempting to reproduce.

Background

Star clusters form in cold, dense molecular clouds. The formation of these star clusters can have a significant impact on their natal clouds through heating and ionizing radiation. Recent studies have suggested that the formation of just a few clusters can disrupt the entire cloud over a short time-scale [1]. Simulations of radiative feedback from clusters are difficult, however, due to the large number of stars formed. We present a model for the radiation output of a cluster to be used in hydrodynamical simulations with FLASH.

GOAL: Create an observationally consistent model for the radiation output of a star cluster to examine radiative feedback effects in realistic molecular clouds

Theoretical Model

- An initial clump mass is converted to stars by random sampling of the Chabrier IMF
- Star formation efficiency of 20% per freefall time is used, and sampling is done every tenth of a freefall time
- Initial gas clump allowed to accrete mass at a constant rate to understand average model behaviour (will not be constant in simulations)
- Each generation of new stars is drawn from total available gas (ie. no accretion onto individual stars) and no stellar deaths
- Track the mass of all stars formed and total luminosity as a function of time to compare to observations

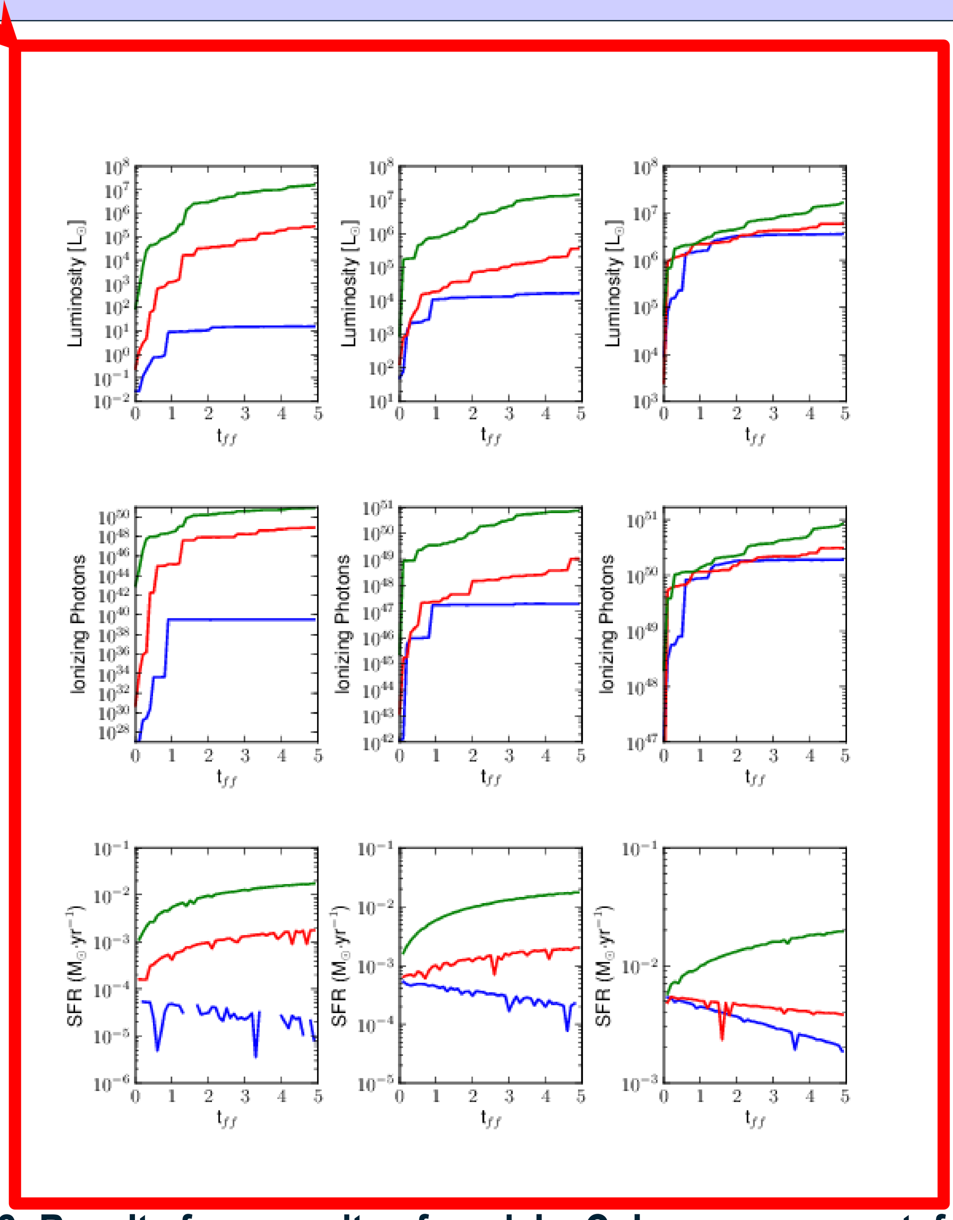

FIGURE 2: Results from a suite of models. Columns represent, from left to right, initial clump masses of 100, 1000, and 10000 Solar masses. Blue, green and red are 10^{-4}, 10^{-3}, and 10^{-2} Solar masses per year

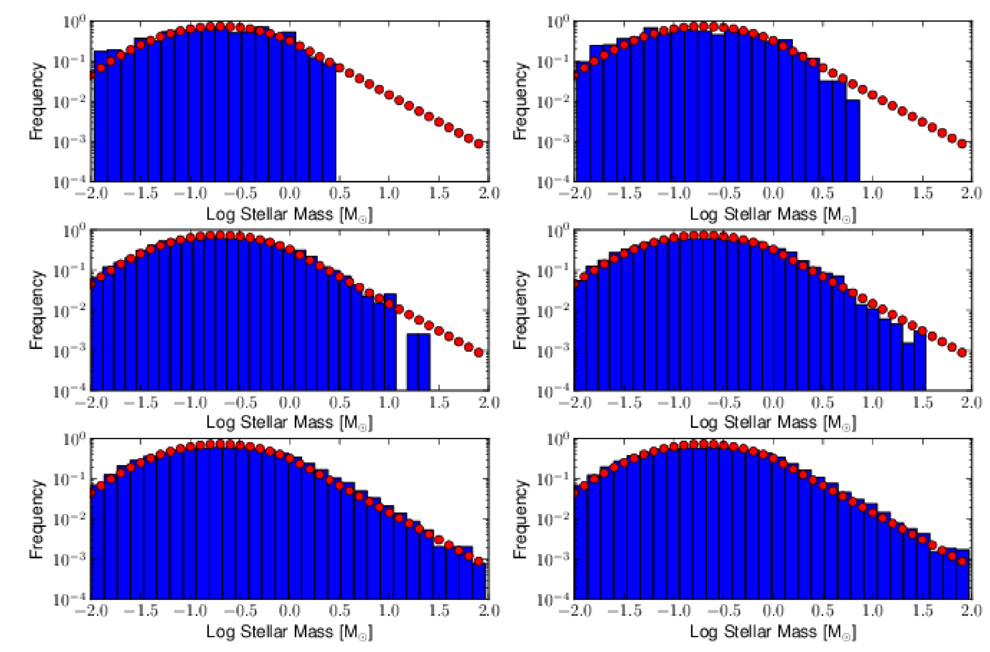

FIGURE 3: The resulting IMF's from simulation where all mass is present in initial clump (right) or all mass is accreted (left). Rows represent clumps with final masses of 500, 5000, and 50000 Solar masses from top to bottom, respectively.

Star formation rates range from 10^{-5} to 10^{-2} Solar masses per year and agree with local star forming regions! [2] [3]

Results

- Our model can reproduce the SFR of local star-forming regions and the number of ionizing photons from stellar evolution codes [4]
- SFR nearly linear with clump mass
- Two regimes:
  - a) Initial reservoir dominated → decreasing SFR and more high mass stars (blue curve)
  - b) Mass accretion dominated → increasing SFR and less high mass stars (black curve)

Differences between regimes diminish with increasing final clump mass

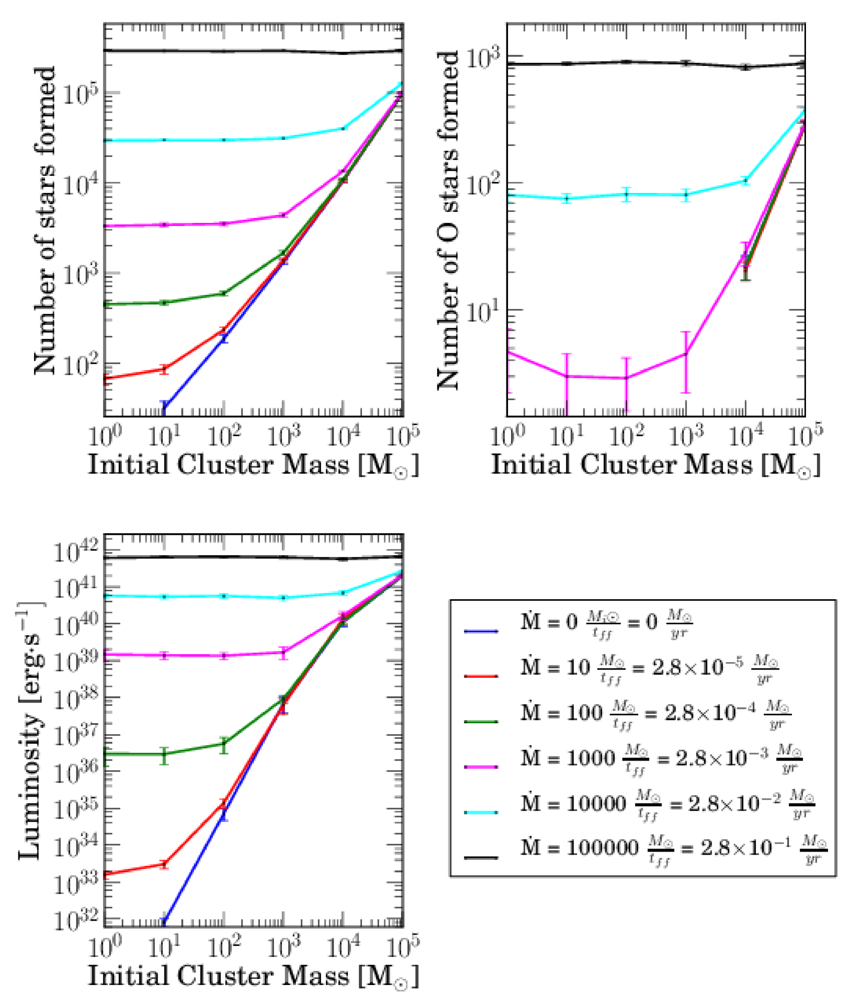

FIGURE 4: Results from a suite of models which varied the initial clump mass and the clump accretion rate.

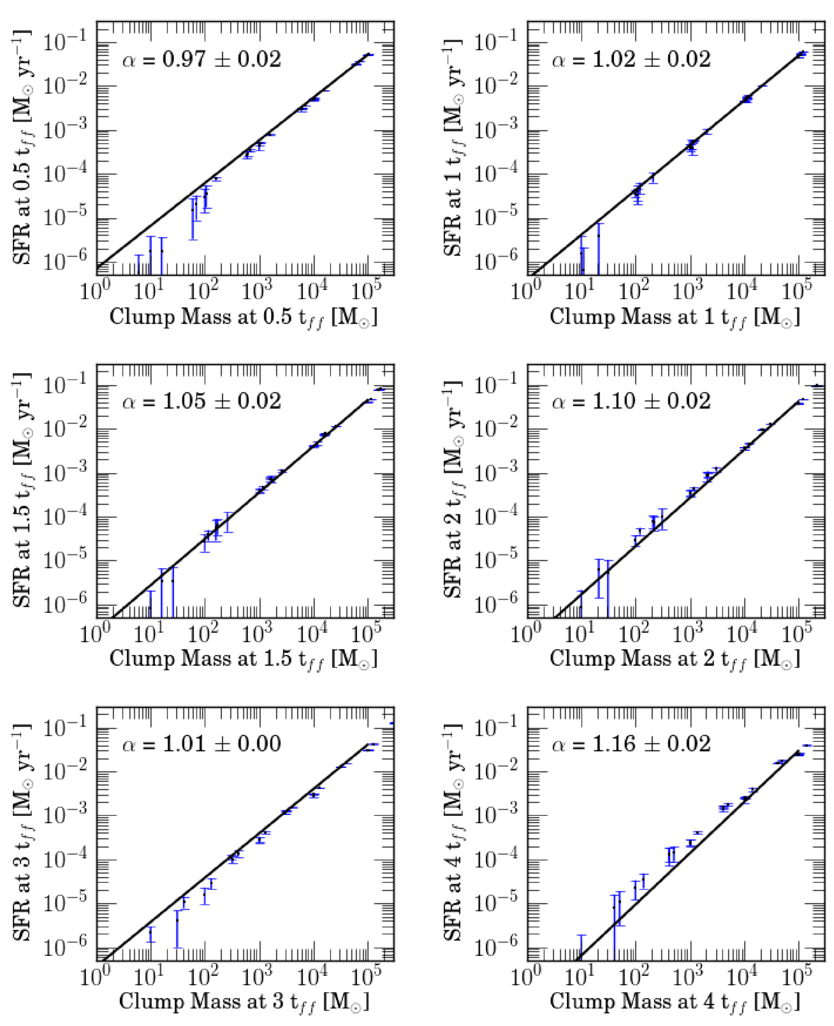

FIGURE 5: The instantaneous SFR vs mass at different times. The best fit powerlaw indices range from 0.97-1.16.

Next Steps

- Model has been implemented into cluster sink particles within AMR code FLASH (Figure 1)
- Coupled to a raytracing scheme to treat radiative transfer
- Currently running a turbulent, 10000 Solar mass simulation including radiative feedback
- Extract: Accretion rates and timescale, cluster mass function, IMF as a function of time, and ionizing flux

References:

[1] N. Murray et al., *ApJ.* , 709, 191, 2010

[2] M. Beltran et al., *A&A*, 552, A123, 2013

[3] L. Chomniuk et al., *ApJ.*, 142, 197, 2011

[4] A. Sternberg et al., *ApJ.*, 299, 1333, 2003