Aim: To test how the variation of cooling rates affects the subsequent fragmentation of an accretion disc due to gravitational instabilities. To investigate how different gradients of cooling rate affects resistance to fragmentation and looks at the results obtained with different histories and resolutions.

Details of simulation:
Smooted Particle Hydrodynamic model of full 3D disc (very similar to Rice et al. 2003, Lodato and Rice 2004). The disc is represented by 250 000 particles (500 000 for higher resolution simulations). The disc extends from radius 0.25 to 25 code units and the accretion radius is 0.25. The star has mass of 1 code unit.

Graph Showing Different Cooling Rate Gradients

Additional Results:

Conclusions:
For the first time simulations have been run that do not start from an unstable cooling rate but approach it more realistically. These results confirm that a fragment forms when it is required to balance a large cooling rate.

There is a suggestion that the disc might be more resistant to fragmentation when driven slowly towards the fragmentation threshold. A slower change in $\beta_{cool}$ results in more resistance to fragmentation with fewer fragments forming at lower values of $\beta_{cool}$ and taking longer to form.

It is possible that an explanation for this is in the modes excited within the spiral structure of the disc, as $\beta_{cool}$ changes more slowly the disc has time to adjust modes to the new stable modes. However, more work is needed to investigate this as no significant change was seen to be relevant.

When a fragment forms it releases heat into the surrounding material and prevents more clumps forming around it.

Further work:
An investigation of other gradients would be interesting to see how the critical value of $\beta_{cool}$ varies for different cooling rate increases.

To study how sensitive the disc are to the critical value repeated full runs of the same simulations would be interesting to see where and where the fragments form.

It is important to test these results with a different code (e.g. ZEUS) to see if the same results are obtained or if it is just a feature of the code. It would be interesting to model the curves of $\beta_{cool}$ in different ways, such as smoother curves, to see how this affects the fragmentation.

Higher resolution runs are needed of all of the simulations to see if differences seen between the 500 000 particle and 250 000 particle runs are significant.

References:
Run S7

Graph Showing Different Cooling Rate Gradients