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Also:

A lead developer of Enzo AMR community code (enzo-project.org) and its replacement, Enzo-E (cello-project.org)

Co-founder of interdisciplinary computational and data science department at MSU (Dept. of CMSE)

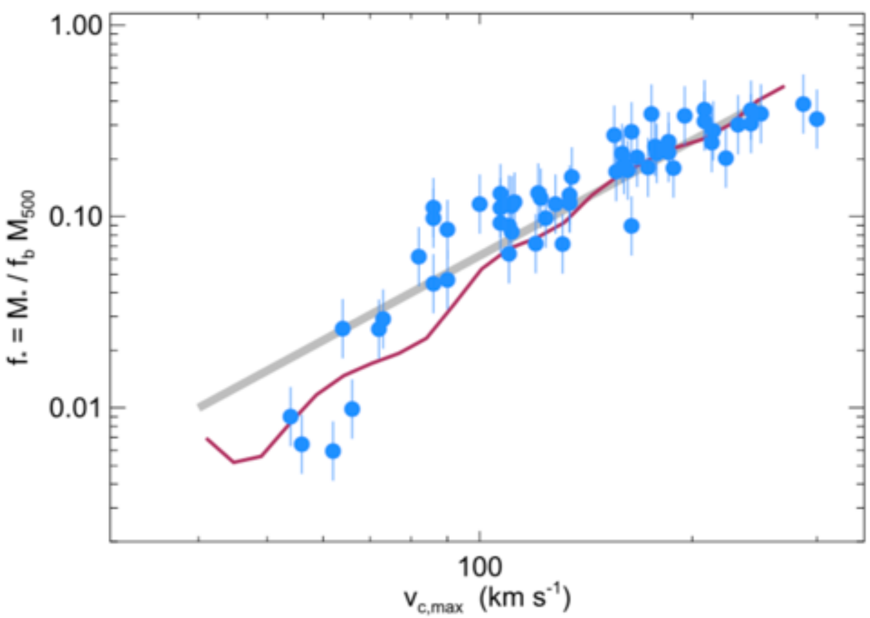
Co-developer of a performance-portable version of the Athena++ code

Why am I interested?

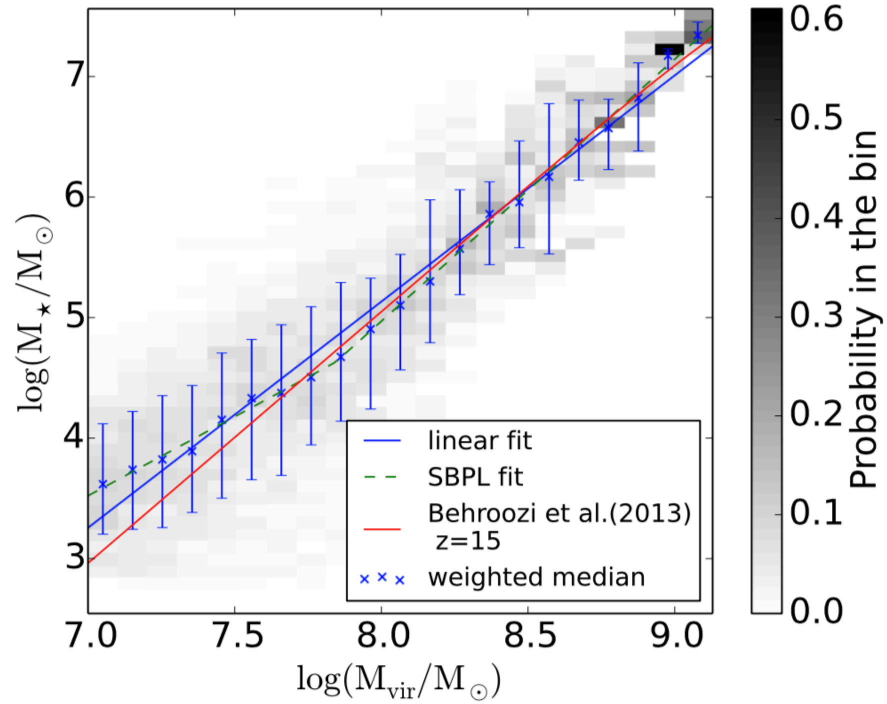
- As model complexity and sophistication of questions that we ask of these models grows (along various axes):
  - Equation implementation grows in importance and impact
  - Infrastructure is harder and more critical
- I’m concerned about ensuring that the interaction between numerical simulation, machine learning based on models and data, and analytic theory (specifically in physics) are effective.

Challenge: understanding the self-regulation of galaxies

Galaxies display striking regularity in their observed and simulated bulk properties: why?



Voit et al. 2015, ApJL, 808:L30
(Local massive galaxies)



Chen et al. 2014, ApJ, 795:144
(Renaissance Simulations)

The simulations

- Modern cosmology simulations are inherently multiphysics and multiscale
- We do our best to model the right physics, using the standard ODE/PDE techniques, and do lots of cross-code comparisons and tests (to the extent possible)
- We observed these scaling/self-regulation properties in simulations <u>first</u>, then tried to understand them analytically (Voit+ papers, others)
- Analytic theory predictions can be very challenging to test directly in this regime (scale, symmetry) − need to do very careful analysis and targeted simulations!

Questions/challenges that emerge

- What does it mean for these complex simulations to “predict” something that we observe in the model and observationally, but don’t understand via analytic theory?
- Related: as computational models evolve to the point where they are used as engines of discovery, how does this change the practical relationship between analytic theory and computational theory?