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From Molecular Clouds to Protostars

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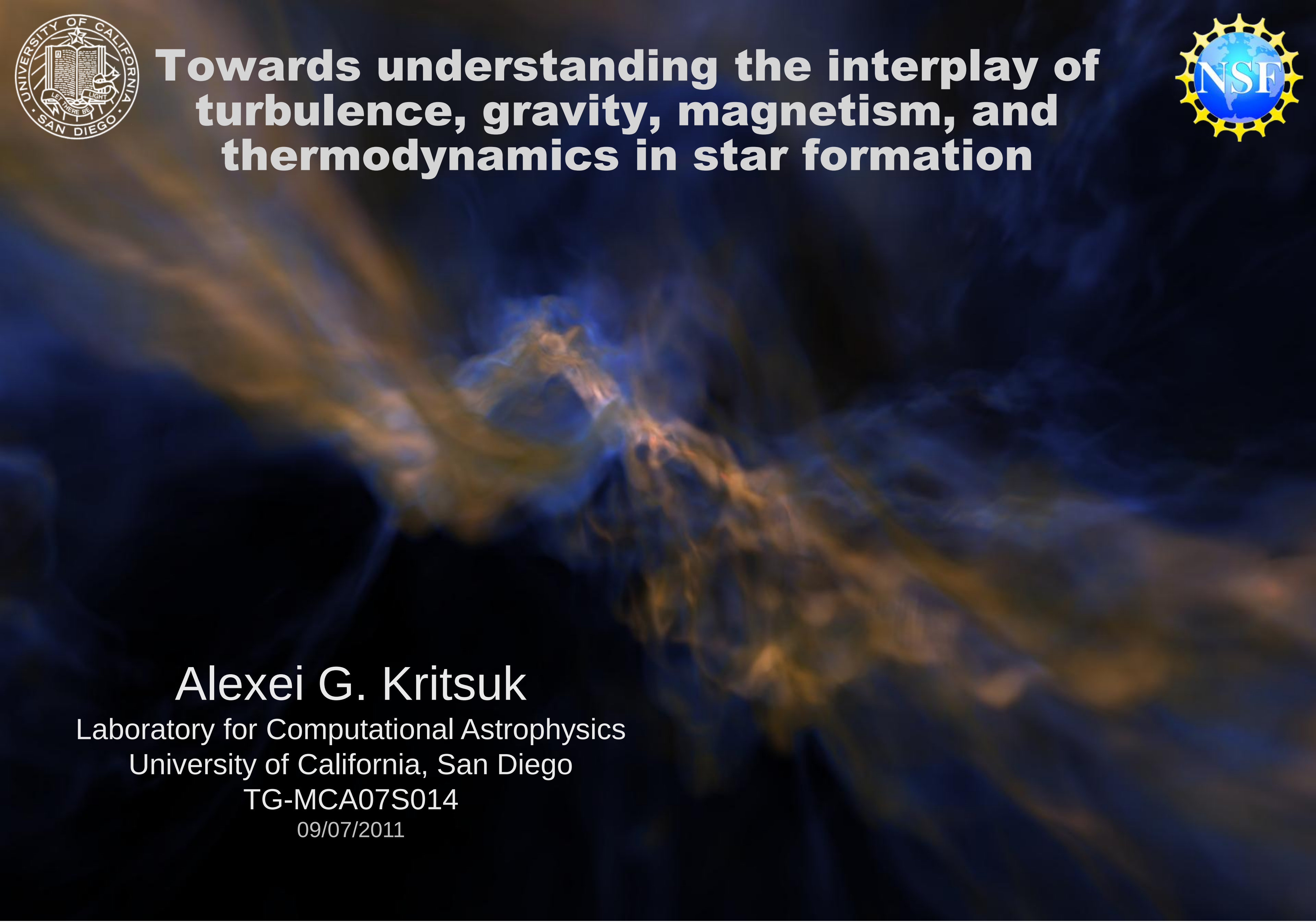

Towards understanding the interplay of turbulence, gravity, magnetism, and thermodynamics in star formation

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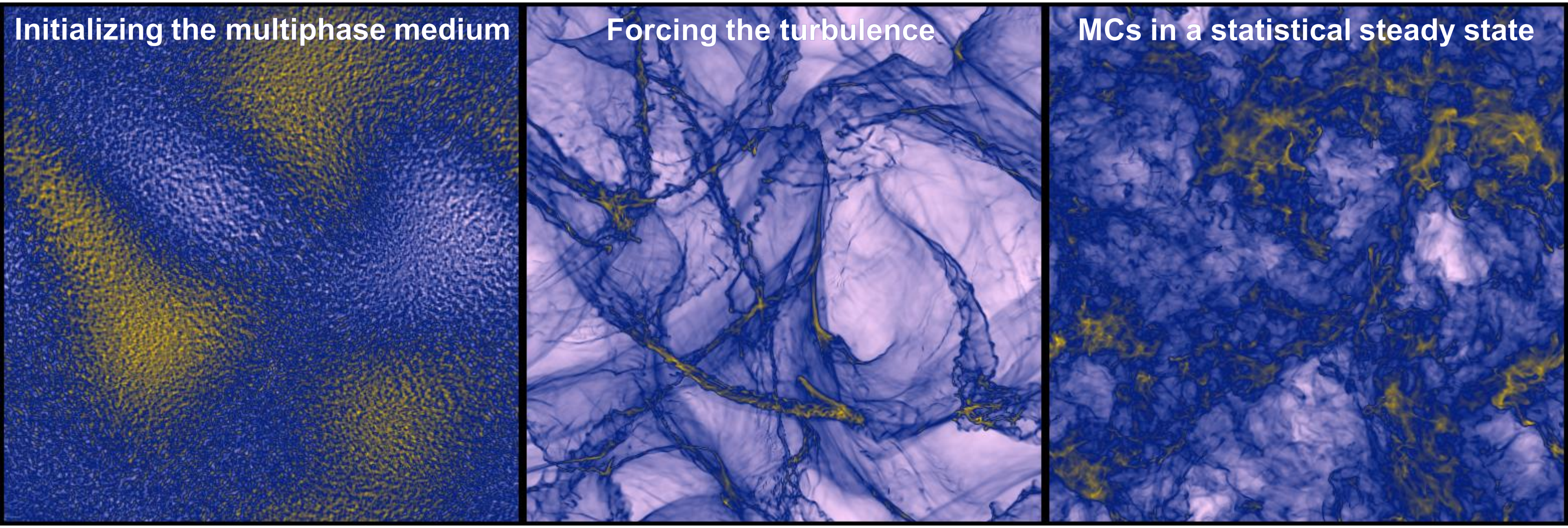
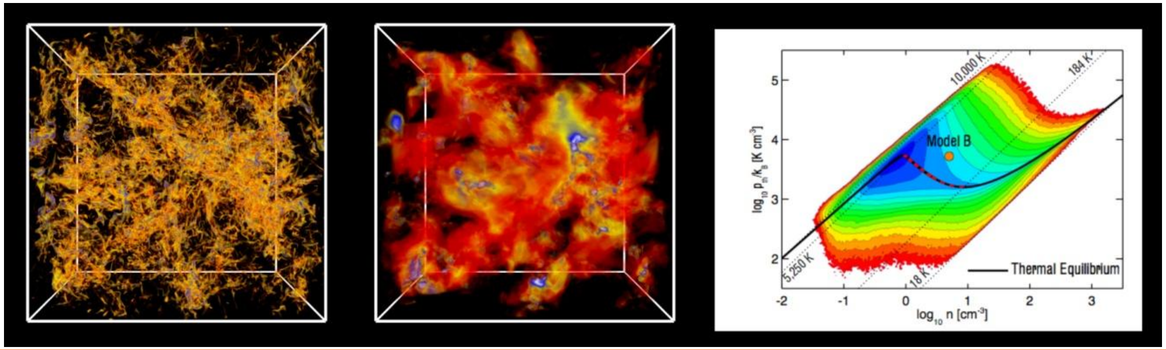
MIST: Multiphase interstellar turbulence



We use high resolution MHD simulations with the PPML solver (Ustyugov et al. 2009, JCP; Kritsuk et al. 2011, ApJ) to model the formation of molecular clouds in the multiphase ISM from first principles. Shown above are column density distributions for three flow snapshots with light-blue indicating low density material and brown-yellow highlighting the molecular clouds



Simulation: Cray XT5 Kraken/Jaguar
Grid: 512^3 MHD
Number of cores: 2,048
Resolved scales: from 200 pc to 0.4 pc

(Kritsuk et al. 2011, Proc. IAU Symp. 270)

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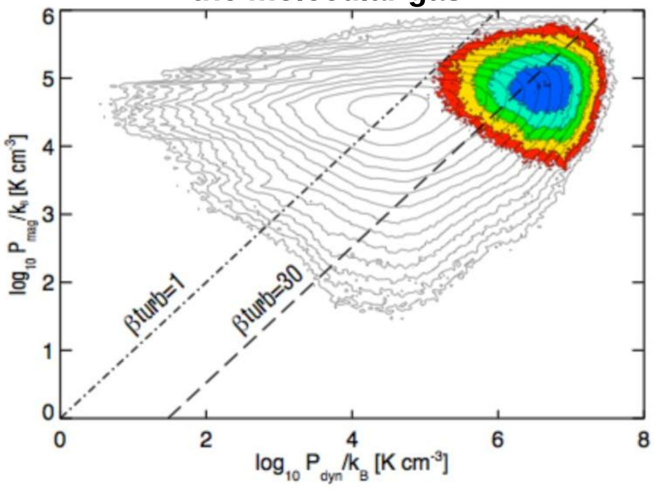
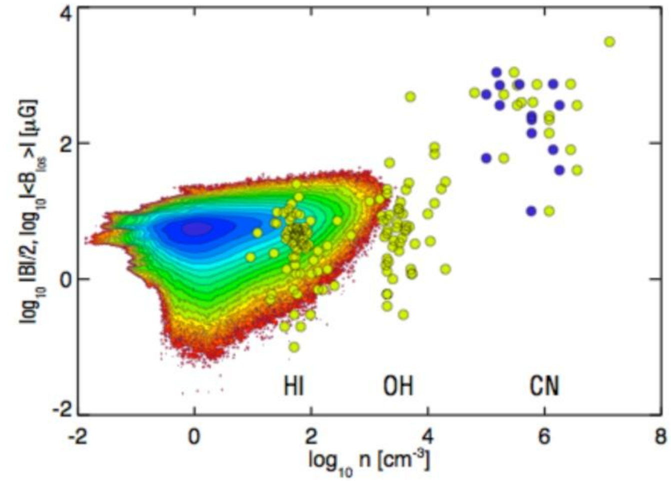
Understanding the role of magnetic fields

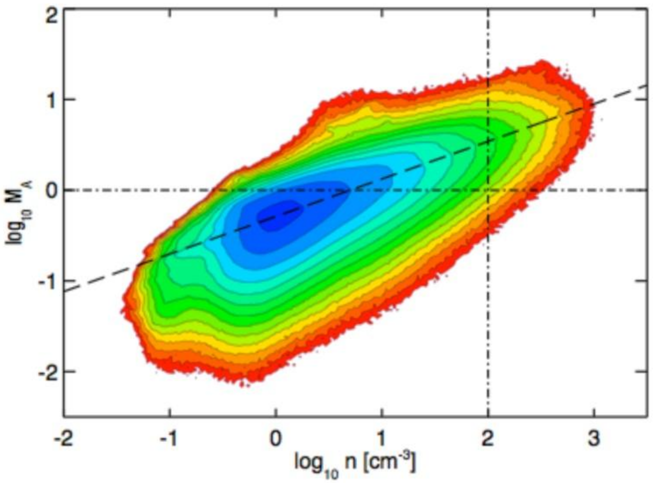
Magnetic vs. dynamic pressure for the molecular gas



The B-n diagram: Simulation vs. observations



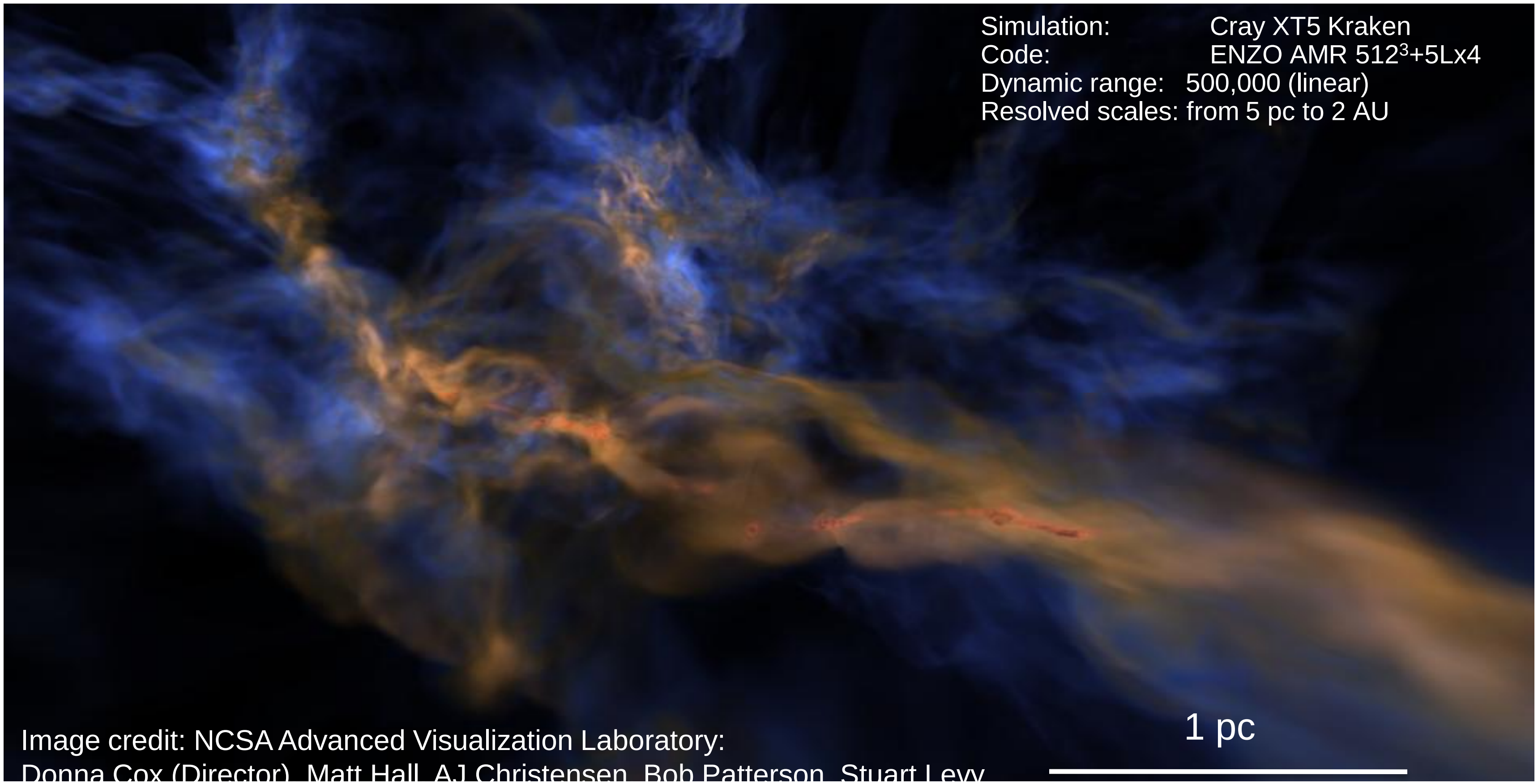
Alfvenic Mach number vs. density



The role of magnetic fields in star formation is a subject of active discussion. Our simulations show that molecular clouds are born super-Alfvenic, i.e. turbulence dominates over magnetic effects globally. This is a consequence of self-organization in the magnetized multiphase turbulence (Padoan et al. 2010, AIPC; Padoan et al. 2011, Proc. IAU Symp. 271). Magnetic fields, however, can be dynamically important on smaller scales in collapsing protostellar cores. This problem is addressed with AMR MHD simulations (Collins et al. 2011, ApJ).

Supersonic molecular cloud turbulence

Stars in the Milky Way form in molecular clouds out of cold (10 K) material arranged in a hierarchical network of dense filaments

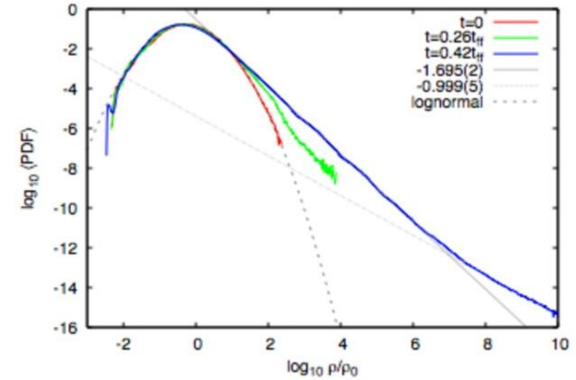


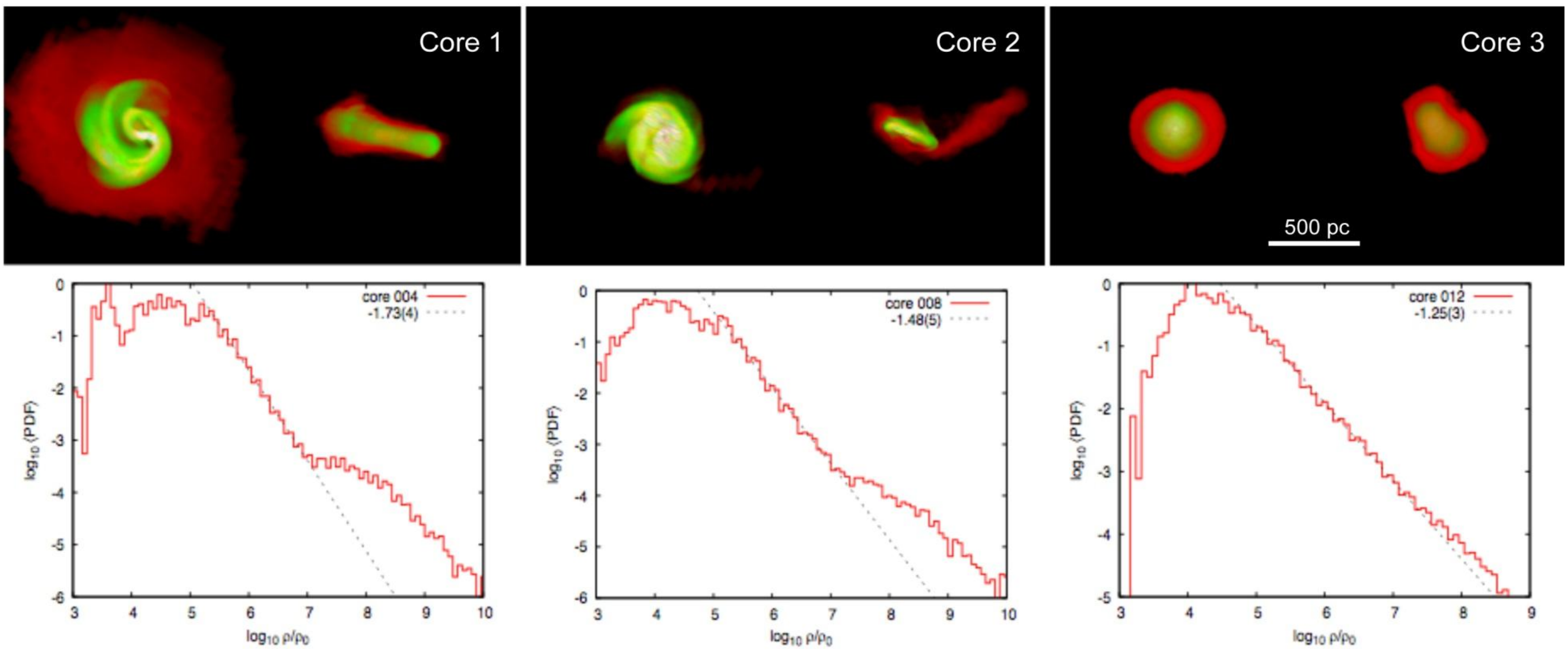
Supersonic molecular cloud turbulence

Interstellar turbulence and self-gravity shape the hierarchical structure of molecular gas from giant cloud complexes (10–60 pc) to clouds (2–20 pc), clumps (0.2–2 pc), and protostellar cores (<0.1 pc)

Mass density distribution in molecular clouds

Collapse of gravitationally unstable structures distorts lognormal shape of the density distribution created by supersonic turbulence (Kritsuk et al. 2011, ApJL). With AMR we are able to trace the power-law tail that develops at high densities for >10 dex in probability with a slope that agrees perfectly with recent observations of the Taurus molecular cloud (Kainulainen et al. 2009)





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