APR09-2009-020087

Abstract for an Invited Paper
for the APR09 Meeting of
the American Physical Society

Hans A. Bethe Prize Talk: The Physics of Stars

DAVID ARNETT, Steward Observatory, University of Arizona

John von Neumann speculated that computers might become sufficiently powerful that they could be used to solve analytically intractable problems numerically (he gave turbulence as an example), and that those "numerical experiments" could be used to provide the insight necessary to develop analytic solutions. A case study will be presented in which we attempt in this way to use computer simulations of 3D turbulent flow in presupernova stars. We find that we can reproduce the simulations surprisingly well—on average—if we replace the viscous term with an effective damping which turns out to be similar to that inferred by Kolmogorov for a turbulent cascade. Stars are gravitationally-controlled thermonuclear reactors. Abundance change (and hence evolution) occurs because of nuclear burning, and mixing. It is now possible to treat this coupled problem in a self-consistent way, free of astronomically calibrated parameters. Implications for stellar evolution, nucleosynthesis yields, core collapse, supernova explosions, helio-seismology, and solar neutrinos will be discussed. It is argued that advances in the treatment of stellar fluid dynamics, along with new developments in laboratory astrophysics, now allow far more reliable predictions of how stars behave.