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Radiative hydrodynamic simulations of turbulent convection and pulsations of Kepler target stars

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Abstract

The problem of interaction of stellar pulsations with turbulence and radiation in stellar convective envelopes is central to our understanding of excitation mechanisms, oscillation amplitudes and frequency shifts. Realistic ("ab initio") numerical simulations provide unique insights into the complex physics of pulsation-turbulence-radiation interactions, as well as into the energy transport and dynamics of convection zones, beyond the standard evolutionary theory. 3D radiative hydrodynamics simulations have been performed for several Kepler target stars, from M-to A-class along the main sequence, using a new 'StellarBox' code, which takes into account all essential physics and includes subgrid scale turbulence modeling. The results reveal dramatic changes in the convection and pulsation properties among stars of different mass. For relatively massive stars with thin convective envelopes, the simulations allow us to investigate the dynamics the whole envelope convection zone including the overshoot region, and also look at the excitation of internal gravity waves. Physical properties of the turbulent convection and pulsations, and the oscillation spectrum for two of these targets are presented and discussed in this paper. In one of these stars, with mass 1.47 M⊙, we simulate the whole convective zone and investigate the overshoot region at the boundary with the radiative zone.

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Keywords

convection, methods: numerical, oscillations, plasmas, stars: Hertzsprung-Russell diagram, turbulence