The 391th Geodynamics Seminar

Linear and nonlinear analysis on the thermal convection of highly compressible fluids
- Implications for the mantle convection of super-Earths -

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EHIME UNIVERSITY GRC GEODYNAMICS RESEARCH CENTER

Abstract

A series of linear and nonlinear analysis is performed on the thermal convection of highly compressible fluids in a basally-heated horizontal layer, in order to deepen the fundamental insights into the mantle convection of massive super-Earths in the presence of strong adiabatic compression together with the strong spatial variations in material properties. Our analysis demonstrated that the nature of thermal convection is strongly affected by the adiabatic compression, in response to the changes in the static stability of thermal stratification in the fluid layer. From the linear analysis on the onset of thermal convection, for example, the strong adiabatic compression yields a thick "stratosphere" of stable thermal stratification in the fluid layer where the vertical motion is significantly suppressed, which results in a shrink of the incipient convection in a thin "troposphere" of unstable stratification. The "stratosphere"-like structure is also obtained in our two-dimensional nonlinear analysis: hot plumes are significantly cooled during their ascent by strong adiabatic decompression, which in turn stop their ascent by diminishing their upward thermal buoyancy. In addition, the efficiency of convective heat transport is reduced by a factor of about four compared with the cases without the effect of adiabatic compression. Our results suggest that the strong effect of adiabatic decompression significantly reduces the vigor of thermal convection in the mantles of super-Earths, which may further imply the lack of hot-spot volcanism on the surface, very slow thermal evolution, and the difficulty in the generation of secular magnetic fields of these planets.

詳細は当センターホームページ：http://www.ehime-u.ac.jp/~grc/をご覧ください
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