The 423th Geodynamics Seminar

Linear analysis on the onset of thermal convection of highly compressible fluids with variable physical properties: Implications for the mantle convection of super-Earths

Dr. Masanori Kameyama (Associate Professor, GRC)

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EHIME UNIVERSITY
GRC
GEODYNAMICS RESEARCH CENTER

Abstract

A series of our linear analysis on the onset of thermal convection was applied to that of highly compressible fluids in a planar layer whose thermal conductivity and viscosity vary in space, in order to study the influences of spatial variations in physical properties expected in the mantles of massive terrestrial planets. The thermal conductivity and viscosity are assumed to exponentially depend on depth and temperature, respectively, while the variations in thermodynamic properties (thermal expansivity and reference density) with depth are taken to be relevant for the super-Earths with 10 times the Earth's. Our analysis demonstrated that the nature of incipient thermal convection is strongly affected by the interplay between the adiabatic compression and spatial variations in physical properties of fluids. Owing to the effects of adiabatic compression, a “stratosphere" can occur in the deep mantles of super-Earths, where a vertical motion is insignificant. An emergence of “stratosphere'‘ is greatly enhanced by the increase in thermal conductivity with depth, while it is suppressed by the decrease in thermal expansivity with depth. In addition, by the interplay between the static stability and strong temperature-dependence in viscosity, convection cells tend to be confined in narrow regions around the “tropopause" at the interface between the “stratosphere" of stable stratification and the “troposphere" of unstable stratification. We also found that, depending on the variations in physical properties, two kinds of stagnant regions can separately develop in the fluid layer. One is well-known “stagnant-lids" of cold and highly viscous fluids, and the other is “basal stagnant regions" of hot and less viscous fluids. The occurrence of “basal stagnant regions" may imply that convecting motions can be insignificant in the lowermost part of the mantles of massive super-Earths, even in the absence of strong depth-dependence in viscosity.

詳細は当センターホームページ：http://www.grc.ehime-u.ac.jp/ をご覧ください
問い合わせ先：出倉 春彦（TEL:089-927-8408, e-mail:dekura.haruhiko.mf@ehime-u.ac.jp）