Carbon paradox in the Earth's inner core

Mingqiang Hou[1,2], Youjun Zhang[3], Jin Liu[1], Ye Wu[4], Jiachao Liu[5], Dongzhou Zhang[6], Vatali Prakapenka[6], Yue Meng[7], Yuming Xiao[7], Paul Chow[7], Jinyuan Yan[2], Martin Kunz[2], Li Zhang[1], Bin Chen[1],Yingwei Fei[8]

[1]Center for High Pressure Science and Technology Advanced Research, Shanghai 201203, China.

[2]The Advanced Light Source, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA

[3]Institute of Atomic and Molecular Physics, Sichuan University, Chengdu 610065, China

[4]School of science, Wuhan University of Technology, Wuhan, Hubei 430070, China

[5]Michigan State University, East Lansing, Michigan 48824, USA

[6]Center for Advanced Radiation Source, University of Chicago, Chicago, Illinois 60439, USA

[7]HPCAT, Carnegie Institution of Washington, Advanced Phonon Source, Argonne National Laboratory, Argonne, Illinois 60439, USA

[8]Geophysical Laboratory, Carnegie Institution of Washington, Washington, District of Colombia 20015, USA

Abstract：

Geochemical, geophysical, and cosmochemical data suggest 0.9mol% to 4.5mol% carbon in Earth's core, which is expected to reduce the density of iron at the Earth's core conditions. Here we report alloying effects of carbon on density and compressibility of iron at high pressure and high temperature. The *P-V-T* relations of hcp-$Fe_{99.1}C_{0.9}$ were measured up to 108 GPa and 2100 K using synchrotron X-ray diffractions upon laser heating and external resistive heating. Hcp-$Fe_{99.1}C_{0.9}$ exhibits obvious Invar effect (small thermal expansion) and softening compared with pure iron. The incorporation of 0.9mol.% carbon into hcp-Fe reduces its thermal expansion coefficients by 51-94%. The softening of $Fe_{99.1}C_{0.9}$ is confirmed by the reduction of Coulomb repulsion between Fe-Fe atoms according to X-ray emission spectra. At inner core conditions (330-363 GPa and ~6000 K), the incorporation of 0.9mol% carbon would densify hcp-Fe by ~1.6%. In terms of the results, we suggest carbon shouldn't be the sole light element in the Earth's core and more other light element(s) is/are required if carbon incorporates into the

Earth’s inner core.