Thermal conductivity of sintered glass beads: measurements, modeling and implication to thermal evolution of planetesimal

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In the solar nebula, there might be planetesimals constructed by aggregates of dust grains. Dust grains could be condensed from nebula gas, and they aggregated each other to form planetesimals. Thermal properties of such particulate materials are unique in vacuum, whose thermal conductivity is extremely low compared with rocks and other solid materials. The planetesimals are considered to be highly porous bodies with a low thermal conductivity which allowed large temperature increase in their interiors by heating of radioactive isotope disintegrations. Then, dust particles could be sintered to each other. It caused drastic increase of their bulk thermal conductivity and mechanical strength, and affected the subsequent internal temperature variation and the maximum temperature of experience in planetesimals. While the thermal conductivity of particulates has been investigated in past experimental and theoretical studies to reveal thermal property of planetary regolith, thermal conductivity of sintered particulates was however rarely investigated so far. Especially the thermal conductivity of weakly sintered particulates is sensitive to the degree of sintering, and can widely change with sintering-neck between particles growing. In this study, we made samples of several degree of sintered particulates using glass beads of 215–855 μm diameter, and observed neck sizes between particles. We measured thermal conductivities of all samples in parallel, and these results were compared with conventional thermal conductivity models of unsintered particulates.
Experimental results showed a clear relationship between the thermal conductivity and the neck ratio, ratio of neck diameter to particle diameter. The thermal conductivity of sintered particles could be scaled by the average neck ratio independently to the particle size in the range of neck ratio < 0.3. This thermal conductivity behavior was smoothly connected to our thermal conductivity model of unsintered particulates in past studies. Based on the above results, thermal calculations of planetesimals were conducted with considering the sintering effect, and peak temperatures in planetesimals were systematically investigated as well as final sintering degree.

Keywords: Thermal conductivity, Sintering, Planetesimal