713th ASRC Seminar

Date：13：30 ～ 14:30 Thursday, March 29

Location： 103 Meeting Room, ASRC Bldg.

Speaker：Ian Farnan

(University of Cambridge)

Title: High-resolution nuclear magnetic resonance of highly radioactive solids: strategies and applications in radiation damage

Abstract: High-resolution nuclear magnetic resonance (NMR) of solids requires that the sample be rapidly rotated at frequencies of several hundred thousand to several million revolutions per minute. Whilst this is standard procedure in materials chemistry and materials science, when the sample contains highly radioactive or fissile material it is a safety challenge. Different approaches to performing the experiments safely will be presented with examples of the resolution enhancement and how it can reveal important, but low abundance structural features that are unobservable by other techniques or with NMR without sample rotation.

An extended example will relate to the quantification of radiation damage by NMR. Radiation damage will often be detected as a density change, a radiation induced swelling or a compaction. Structural changes resulting in this density change are generally detected by diffraction-based techniques. Nuclear magnetic resonance (NMR) does not require a regular array of diffracting atoms and detects crystalline and amorphous material equally. Thus, it is very well-adapted to investigate radiation damage. Development of high-resolution radiological NMR has allowed materials containing isotopes such as ^{238}Pu and neutron-activated materials to be analyzed and to describe radiation damage on a truly atomistic scale by spin-counting number fractions of displaced atoms. Examples will be given from isostructural and isoelectronic silicate and phosphate systems ($ZrSiO_4$ and YPO_4), which show that this measure of radiation damage can detect damaged material before swelling occurs. The use of ^{10}B(n, a) damaged materials has allowed the relative effect of alpha particles and alpha recoils to be measured. Differences in the radiation recovery mechanism of these two systems lead to very different numbers of permanently displaced atoms at room temperature. This appears to be related to the predominance of unpolymerised Q^0 tetrahedral units in the amorphous fraction of YPO_4 and the presence of polymerised Q^1 and Q^2 units in amorphous $ZrSiO_4$.

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