Nuclear resonant spectroscopy in the laser-heated diamond anvil cell

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The introduction of nuclear resonant scattering techniques to third generation synchrotron radiation facilities around the world has been very successful over the last decade. New opportunities for the study of vibrational and magnetic properties of condensed matter have opened up for research areas like biophysics, geophysics, and nanoscience. In particular, the determination of the vibrational density of states with nuclear resonant inelastic x-ray scattering (NRIXS) and the study of valences and magnetic properties with synchrotron Mössbauer spectroscopy (SMS) provided remarkable results [1].

In this contribution, we discuss the combination of nuclear resonant spectroscopy with diamond anvil cell technology and its impact on the scientific area of geophysics. We will briefly address the specifics of NRIXS, a method that uses probe nuclei with suitable resonances to measure the vibrational density of states, and SMS for the determination of valences, spin states, and magnetic ordering analogous to conventional Mössbauer spectroscopy. Both methods are very sensitive to small amounts of material and take advantage of the high brilliance of synchrotron radiation, which makes micrometer-sized x-ray beams with high intensity possible. These properties together with the isotope selectivity allowed NRIXS and SMS investigations on materials under pressures in the Mbar regime using diamond anvil cells and Laser heating [2-4].

Even though ^{57}Fe has spawned the largest interest so far, we will review the selection of other suitable nuclear resonances that could become important for future applications. Nuclear resonant spectroscopy methods, which include NRIXS and SMS, continue to evolve with the development of new instrumentation, the improvement of synchrotron radiation sources, the increased diversity in nuclear resonant methods, and the synergy with other experimental techniques like x-ray diffraction, inelastic x-ray scattering, and x-ray fluorescence analysis. We will identify different evolutionary branches and speculate about their potential impact on the experimental realizations and the applications of nuclear resonant spectroscopy.

This work is supported by the U.S. DOE-BES, Office of Science, under Contract No. W-31-109-Eng-38.

References

[1] – W. Sturhahn, J. Phys.: Condens. Matter **16**, S497, (2004)
[2] – J.-F. Lin, W. Sturhahn, J. Zhao, G. Shen, H.-k. Mao, R. J. Hemley, Geophys. Res. Lett. **31**, L14611, (2004)
[3] – J. Zhao, W. Sturhahn, J.-F. Lin, G. Shen, E. E. Alp, H.-k. Mao, High Press. Res. **24**, 447, (2004)
[4] – J.-F. Lin, W. Sturhahn, J. Zhao, G. Shen, H.-k. Mao, R. J. Hemley, Science **308**, 1892, (2005)