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X-ray Raman scattering spectroscopy

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For elements with low atomic number, or shallow absorption edges falling in the energy range below ~1 keV, x-ray absorption studies are often limited by surface sensitivity and the necessity of a vacuum environment, making bulk-sensitive measurements and for example studies of liquids difficult. An exciting alternative is provided by X-ray Raman scattering (XRS) spectroscopy. It is used to measure a photon-in-photon-out process, where a hard x-ray photon loses only part of its energy creating an excitation of an inner core electron. As such, it is the x-ray analogue of electron energy loss spectroscopy. The advantage of XRS is that the incident photon energy can be chosen freely and thus low-energy absorption edges can be studied with high-energy X-rays. Thus XRS is becoming increasingly popular since it allows for bulk-sensitive measurements of inner core spectra where the corresponding x-ray absorption threshold falls into the soft x-ray regime. This lifts all constraints on the sample environment inherent to soft x-ray studies, and offers access to bulk-sensitive information on solids, liquids and gases as well as systems in enclosed sample environments such as high-pressure cells. For example the microscopic structure of water within the supercritical regime has been recently studied using the oxygen K-edge excitation spectra measured by XRS, yielding new information on the hydrogen-bond network of water in extreme conditions [1]. Another important feature of XRS is that it allows for other than dipole transitions to be studied, thanks to an practically unlimited range of momentum transfer offered by hard x-rays. These higher order multipole excitations can yield novel information on the electronic structure, not accessible by many other spectroscopies [2]. The availability of XRS instruments at third-generation synchrotron radiation sources has made highly accurate XRS measurements possible. XRS can be even used as a contrast mechanism in three-dimensional X-ray imaging [3]. In this contribution, the capabilities of XRS and recent examples of novel studies allowed by it will be reviewed.

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