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In-vivo iron measurement through nuclear resonance fluorescence

Abstract: In-vivo quantitative measurement of iron has been the focus of several studies related to iron disorders in the human body. Techniques such as SQUID and MRI have been used to detect liver iron stores in patients afflicted with hemochromatosis and thalassemia. Here we present a gamma-stimulated spectroscopy method to detect iron in an aqueous sample through nuclear resonance fluorescence. A high-energy tuned gamma-ray beam was used to excite characteristic gamma emission from an iron sample suspended in water. The gamma-beam was generated using the free-electron-laser source at Duke University and tuned to 6.93 MeV to resonate with the 6926 keV energy state in natural iron (56-Fe). The beam was collimated and focused onto a sample of natural iron immersed in water corresponding to an iron concentration of 180 mg/g. An identical phantom of copper immersed in water was used to obtain an estimate of the background noise from the spectroscopic acquisition setup. Emitted gamma spectra were generated for each sample using a high-purity germanium (HPGe) detector and background corrected using time-of-flight techniques. The resulting spectrum showed a strong gamma line at 6926 keV originating from 56-Fe in the sample. This experiment demonstrates the ability to selectively stimulate and quantify a specific energy level in iron through nuclear resonance gamma-stimulated spectroscopy. Through tomographic imaging the technique can be expanded to obtain three-dimensional quantitative maps of iron stores in the liver or other organs in the body in a manner that is both non-invasive and in-vivo.