Some Facts About Nuclear Forces and Evidence of their Range being Longer than People Believe

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Nuclear forces are believed to have ranges around 2 fermi and beyond that range, only electrostatic force is relevant. Before trying to make theories about the phenomena of nuclear reactions observed in solids, it is important to revise critically the existing experimental literature and nuclear theory to check if current models are coherent and if they could explain the observed phenomena. The first step is to check the current nuclear models, the second is to analyse the neutron cross-section data, the third is to discuss coherence between empirical data and models, the fourth is to identify the order of magnitude of nuclear forces range, the fifth is to revise the full height of Coulomb barrier. It was found one isotope (Gadolinium-157) that can attract a thermal neutron at least at 2781 fermi and repulses neutrons at 179 Fermi. It was also found that the plane projection of volumes where neutrons are directly captured is distinct of the projection of the volume where neutrons are scattered for most isotopes. But Kryptonium, Ruthenium, Xenonium, Iridium, and Mercury elements seem having their scattering volumes covered by the absorption volumes, or not having a scattering volume at all. Ca-44, Ca-48, Ni-64, Se-74, Te-123, Dy-162, Hf-177 and W-186 isotopes seem having a partial screening of their scattering volume by the absorption volume. Resonance capture volumes seem to be independent of direct capture volumes and have interface with scattering volume. Three facts suggest absorption volumes are consequence of nucleons arrangement, assuming an FCC nucleus model. The first is that a single additional neutron may change the order of magnitude of absorption radius (like He-3 to He-4). Second, excited states also change absorption cross-sections, like Na-23 whose first excited state increases absorption cross-section and Cl-37 whose first excited state decreases absorption cross-section. Third, neutron capture resonance depends on existence of an excited state of the compound nucleus (target nucleus plus the neutron) with energy larger than this neutron binding energy. In other words, to have a resonance, the target nucleus needs to have two places available for a neutron, and the energetic distance between them needs to be larger than a minimum (the very neutron binding energy). Compared to Coulomb forces, the nuclear forces attracting neutrons are weak, about 6 orders of magnitude smaller than electrostatic repulsion at mean thermal neutron capture radius.

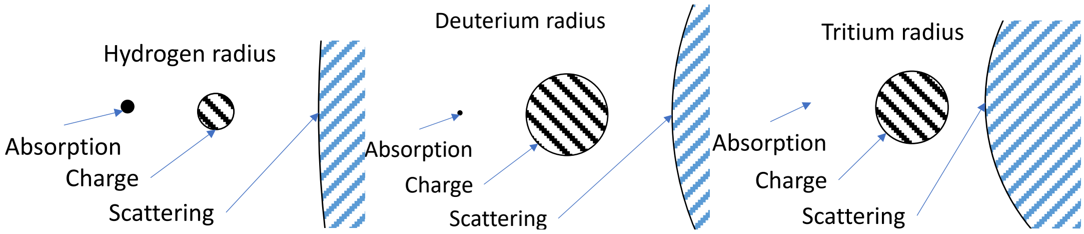

Figure 1 – Hydrogen isotopes Absorption, Charge and Scattering radius. Note scattering and absorption radius decreases with number of neutrons and charge radius is maximum for Deuterium. Long range nuclear forces could explain such radius variations according with number of neutrons.