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The (^{6}Li,^{6}Li$'$[3.56 MeV]) reaction as a novel probe for studying the inelastic neutrino-nucleus response in astrophysical scenarios

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We have proposed to perform a (^{6}Li, ^{6}Li$'$[3.56 MeV]) experiment at $E_{^6\mathrm{Li}} = 100$ MeV/u at 0° with CAGRA and GRAND RAIDEN. In this reaction the ejectile is in the 3.56-MeV excited state which decays directly to the ground state by γ emission, allowing the reaction channel to be identified via the detection of the 3.56-MeV γ rays with CAGRA. This reaction exclusively excites GT_0 transitions, namely the pure spin- and isospin-flip transitions in the inelastic channel ($\Delta S = 1, \Delta T = 1, \Delta T_z = 0$), whose transition strength [$B(\mathrm{GT}_0)$] is directly connected to, e.g., the inelastic neutrino-nucleus scattering (INNS) cross sections. We plan to measure five targets, ^{12}C, ^{24}Mg, ^{56}Fe, ^{93}Nb, and ^{124}Sn, with the aim to establish this new technique as well as address various astrophysical topics including nucleosynthesis (r- and ν-processes), supernova neutrino detection, supernova evolution and modeling. In addition, many astrophysical models rely on neutral-current and charged-current neutrino interactions with heavy nuclei for which very little data exists, therefore this experiment and the ^{6}Li reaction probe are of high scientific importance. The success of this project could lead to future plans that employ the (^{6}Li, ^{6}Li$'$) reaction in inverse kinematics to study GT_0 responses of rare isotopes.