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Laser Spectroscopy of Californium-253,254

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The 60-day spontaneously fissioning isotope californium-254 is the most neutron-rich known isotope of this element. Due to its anomalously long half-life, it is predicted to have a particularly high impact on the brightness of electromagnetic transients associated with neutron star mergers on the timescale of 10 to 250 days [Zhu et al., *AJL* 863, L23 (2018)]. Experimental information on Cf-254 is scarce, owing to limited production capabilities in the laboratory. We have performed optical spectroscopy on this and other neutron-rich isotopes in this part of the nuclear chart. For this, targets of heavy Cm isotopes were neutron-irradiated at the High Flux Isotope Reactor, Oak Ridge National Laboratory (ORNL), Oak Ridge, TN, USA, to breed transcurium isotopes including Cf-252 and Es-253,254. A chemical separation performed at ORNL's Radiochemical Engineering Development Center yielded the Es fraction, which also contained some Cf-252. This sample was shipped to Johannes Gutenberg University Mainz (JGU), Mainz, Germany, via Florida State University (FSU), Tallahassee, FL, USA, and then sent to Institut Laue-Langevin (ILL), Grenoble, France, for a second irradiation with thermal neutrons to produce more neutron-rich isotopes including the 40-d isotope Es-255, which continuously feeds the 20-h Fm-255, as well as 18-d Cf-253 and 60-d Cf-254. Laser resonance ionization spectroscopic studies were performed at the RISIKO mass separator at JGU. In californium, the hyperfine structure of the 420 nm ground state transition in Cf-253 and the isotope shift of Cf-254 in the 417 nm and 420 nm ground-state transitions were determined with high resolution down to 140 MHz FWHM by using the Perpendicularly-Illuminated Laser Ion Source and Trap (PI-LIST). These data provide a basis for a King plot analysis of the optical spectrum of Cf-254 based on known results in lighter californium isotopes, where substantially more data are available.

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