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Spots, Faculae, and Ages: The Promise of Rotation with* Roman *and Deep Learning
WIDE-FIELD SCIENCE – REGULAR

We propose to improve our existing open-source tools to determine the efficacy of *Roman*'s proposed time domain survey's strategies in measuring stellar rotation periods, inferring gyrochronological ages, and distinguishing between magnetic structures on stellar surfaces.

The *Roman* mission is set to perform infrared time domain surveys, particularly in the Galactic bulge, but also at high latitudes. The *Kepler* mission showed us that large time domain datasets allow the measurement of rotation periods of stars across the HR diagram through the modulation of stellar brightness by magnetic spots. Those rotation periods can be used to infer precise (<10% error) ages using gyrochronology, even into the M-dwarf regime where most of *Roman*'s exoplanet hosts will be. However, work with the TESS mission has suggested that systematics and complex observing strategies like those proposed for *Roman* can make the extraction of periods with conventional techniques extremely challenging.

We have developed a deep learning technique that can estimate rotation periods in these challenging conditions, as well as a suite of simulations to determine how much additional information about star spot configurations (e.g., relative spot temperatures, sizes, evolution) can be extracted from the data. This technique has been used successfully to obtain periods from TESS and is flexible and adaptable to other missions. We will therefore 1) construct a suite of simulated spot-modulated light curves following *Roman*'s observing strategy in multiple photometric bands, 2) adapt our deep learning framework to predict what ranges of rotation periods, gyrochronological ages, spot amplitudes, and spot characteristics *Roman* will detect, and 3) evaluate the tradeoffs of the *Roman* survey strategy for measuring stellar rotation.

We will predict yields for stellar rotation and spot properties observable with *Roman* and suggest a survey optimization to extract the most stellar astrophysics science from *Roman*. Our modeling, simulation, and machine learning tools will provide public *Roman* analysis software beyond what the Science Centers will provide. Finally, the proposed work will support NASA objectives in studying the evolution of stars and enhance *Roman*'s exoplanetary science impact by placing its discovered planets into the context of galactic evolution.