Selected Project List

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1. Solar Analogs

As an ancillary aspect of its planet-hunting goals, the Kepler mission and its K2 succcessor have observed nearly 400,000 stars for periods ranging from 3 months to 4 years, producing light curves of a quality far better than is achievable from the ground. From these light curves we can derive levels of activity and rotation periods for the cool stars in the sample, which in turn can be used to analyze stellar age-rotation-activity relations. In particular, I have an ongoing NASA-supported project to identify and characterize all of the solar analogs in the K2 observing fields, both in order to analyze them as a consistent sample and to provide a well-defined sample for future long-term study. A useful reference to start with is https://www.swsc-journal.org/articles/swsc/full_html/2016/01/swsc160019/swsc160019.html.

Participating students could be involved in data analysis of Kepler/K2 data using existing tools (MATLAB/Python) as well as modifying and writing new software. We will also collect archival data from other space-based missions to build a more complete picture of our targets, and do asteroseismology on about 30 of the brightest targets. In addition, we support the project with remote ground-based observing using the SARA telescopes (http://saraobservatory.org), allowing for participation both as observers and in data reduction and analysis. Finally, we're also funded to do some public outreach activities in conjunction with Calusa Nature Center and Planetarium, so there are ways to get involved that way as well.

The project is part of a larger-scale research effort under the auspice's of NASA's "Living With a Star" program (https://science.nasa.gov/about-us/smd-programs/living-with-a-star). The team meets roughly twice a year at various locations, and participating students may have the chance to attend a meeting, as well as travel to a conference to present results. [Long-term project]

2. Galactic Archaeology

I am part of a large international consortium performing asteroseismology (see https://en.wikipedia.org/wiki/Asteroseismology, https://arxiv.org/pdf/1205.6407.pdf) on a large sample (thousands) of evolved red giant stars using K2 photometry. Asteroseismology combined with ground-based data allows us to determine stellar properties such as radius, mass, distance, and age. Because red giants are intrinsically bright, we can successfully perform asteroseismology even on stars at distances of >10 kpc, and thus map the structure and evolution of our Galaxy. Good references to look at include http://iopscience.iop.org/article/10.1088/2041-8205/809/1/L3/pdf and https://arxiv.org/pdf/1611.09852.pdf.

Participating students could be involved in data analysis of Kepler/K2 data using existing tools (MATLAB/Python) as well as modifying and writing new software. In addition, there is a need for testing both new and modified software on existing data sets. Participating students may have the chance to travel to a conference to present results. [Long-term project]

3. Wide Binaries

As stars like the Sun age, they spin more slowly due to the loss of angular momentum through their winds. The idea behind "gyrochronology" is that there's a *general* relationship between the rotational period and the age for such stars. However, it's not clear how single-valued such a relationship is, and recent evidence is inconclusive. This project involves finding binary stars, which therefore formed at the same time and thus are the same age, but which are separated by far enough that (a) there is minimal direct interaction between the stars, and (b) we can measure rotation periods for both components. By comparing rotation rates for both components, we can test the suppositions of gyrochronology. The project is a collaboration with Drs. Terry Oswalt and Tomomi Otani (Embry-Riddle) and Dr. Jim Davenport (Western Washington & Univ. Washington). Some useful references include https://arxiv.org/abs/1612.00070 and ttp://adsabs.harvard.edu/abs/2017AAS...22924026O.

Participating students could be involved in data analysis of Kepler/K2 data using existing tools (MATLAB/Python) as well as modifying and writing new software. Participating students may have the chance to travel to collaborator's sites, as well as to a conference to present results. [Medium-term project]

4. Hardware projects

I'm involved in three different local, small-scale, astronomical hardware projects. All are in their early stages.

A. Sun-as-a-star Spectrograph: Conversion of a commercial astronomical spectrograph to one which views the sun as an unresolved source using an astronomical fiber. For some existing similar projects, see https://pepsi.aip.de/ and http://www2.lowell.edu/users/jch/sss/; I was part of the original team for the latter. This would involve some basic optical hardware work, as well as construction/testing/checkout of the enclosure and supporting mechanical structures, along with interfacing the existing operations software for the spectrograph into a system which can operate remotely. [Long-term project]

B. Lucky imaging of potential exoplanet host stars: Construction and testing of an instrument to do high-speed two-filter imaging of exoplanet host stars. The hardware is off-the-shelf and in-hand, so the next step would be off-campus testing using a portable telescope, along with learning how to reduce and analyze the data. My plan is to use existing tools used by amateur astronomers to reduce the learning curve. If the proof-of-concept works, then we would test on our 0.4-meter telescope and then move to a 1-m class instrument at a better site. [Short-term project]

C. North Polar Exoplanet Search telescope: construction and commissioning of a small dedicated telescope to continuously monitor the region immediately surrounding the North celestial pole in a search for transiting exoplanets, particularly gas giants with orbits >1 AU. Parts of the hardware are in-hand already (almost everything except the actual telescope), so we'd start with site selection and preparation and overall system design (both hardware and software). [Long-term project]

5. Theory/Computational Projects

A. LSST Exoplanets: The Large Synoptic Survey Telescope (LSST; https://www.lsst.org/) is an 8.4 meter telescope under construction in Chile which will be used to image the entire southern sky with a typical cadence of a few days over at least a decade. For some sense of the implications of this project for stellar work, you can take a look at the LSST Stars Study Group Report (https://arxiv.org/pdf/1607.04302.pdf), or if you have more time, you can look at the overall report (https://arxiv.org/pdf/1610.01661.pdf). LSST will inevitably detect transiting planets as it operates (https://arxiv.org/pdf/1408.2305.pdf). The focus has been on "hot Jupiters", large planets with short-period orbits, because LSST is really optimized for these. However, it will also detect a large number of single transits from planets with much longer-period orbits, and that population is poorly studied. I'd like to model how many such planets LSST might detect, and what we might learn from it. This will require simple software writing in the language of your choice (Python/MATLAB preferred, but I could be convinced otherwise). [Short-term project]

B. Stellar Rotational Evolution: Some of the observational projects above reflect tests for gyrochronology. I'm also interested in a different, more theoretically motivated, look at gyrochronology. The angular momentum loss low-mass stars experience as they age is mediated by their outflowing winds, and made much more efficient by the coupling of those winds to the stellar magnetic field. About 20 years ago, I speculated that changes in the morphology of the stellar magnetic field as the stars age would lead to changes in that coupling which would effect what we now call gyrochronology (http://iopscience.iop.org/article/10.1086/304374/pdf). Since then there has been some work in this area, but results are not really conclusive (for a contrary view to mine, see https://www.aanda.org/articles/aa/pdf/2007/38/aa5470-06.pdf). I'd like to follow up on this and see what is the *maximum* impact this effect can have, and how important it might therefore be to understanding the existing unanswered questions regarding gyrochronology. [Short-term project]

Short-term project = should be able to complete in one academic year
Medium-term project = 1-2 years
Long-term project = likely more than 2 years