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To the NESSF Committee:

I am writing to recommend Sharon (Xuesong) Wang for the NASA Earth and Space Science Fellowship. I write as her thesis adviser, having supervised her research for multiple years, and as her instructor in my Stellar Atmospheres class. Sharon has proven her versatility and capacity for outstanding scholarship in her time at Penn State, and her thesis will be an important advance in exoplanetary astronomy. I have reviewed her proposal "Finding the Lowest Mass Exoplanet with Improved Radial Velocimetry" and give it my strongest endorsement.

Ms. Wang is improving the radial velocity precision of the Hobby-Eberly Telescope (HET) and the telescope at Keck Observatory for the purpose of detecting planets orbiting the nearest Sun-like stars. Of particular utility is using these telescopes to study the planetary systems the *Kepler* spacecraft is discovering with rocky planets in the "Habitable Zone"[1]. HET and Keck are the only two large (8–10 meter class) Northern Hemisphere telescopes capable of precise radial velocity measurements, which we use to discover and characterize the orbits of planets orbiting other stars. Sharon will also apply this expertise to the MINERVA project at Palomar mountain, which employs small (0.7-meter) telescopes to find planets orbiting the nearest stars, and will perform important *TESS* followup observations.

Ms. Wang has already spent over a year building a working precise Doppler pipeline for the HET. She adapted a standard software package to Hobby-Eberly Telescope High Resolution Spectrograph spectra, and successfully developed a turnkey system for High Resolution Spectrograph raw data from multiple configurations. Sharon also developed her own software to perform parameter estimation of radial velocity curves using a robust bootstrapping procedure that can handle data from multiple telescopes, multiple planets, and that can be used for transit time prediction. This code is currently the basis for a fruitful collaboration with multiple collaborators to find transiting planets orbiting the nearest stars. All of these efforts have culminated in a first author paper[2] for Sharon, recently published, announcing the discovery of a second planet orbiting the star hosting the first planet discovered with the HET.

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[1] The region around a star where an Earth-like planet or moon would have a surface temperature consistent with liquid surface water.

[2] http://adsabs.harvard.edu/abs/2012ApJ...761...46W

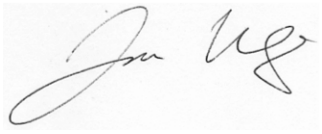
Ms. Wang has also successfully implemented the precise Doppler code of the California Planet Survey from the Keck and Lick planet searches to run at Penn State on HRS and Keck data, which required reading, learning, and often rewriting thousands of lines of (often poorly-document) legacy IDL code. It was a Herculean effort, and now Sharon's code produces radial velocities that match the best published precision for HRS data, and matches the precision of the Keck Doppler pipeline on Keck/HIRES data.

Ms. Wang's current effort involves further improvements to the RV pipeline, most notably proper treatment of atmospheric (telluric) absorption features and a thorough error budget including the effects of fiber-optic modal noise and imperfect iodine template spectra. These efforts have improved the precision of the Keck pipeline, removing 1 m/s of systematic noise due to telluric features from one of our best standard stars. This development will certainly improve the ability of Keck to characterize low-mass planets, and points the way to improving the precision at HET as well, when it comes back online from its upgrades. We are eager to apply Sharon's new code to such low-amplitude Keck systems as GJ 581, tau Ceti, and 55 Cancri.

In sum, thanks to Sharon's continued efforts, HET/HRS and Keck are poised to play an even more critical role in NASA's continued followup of *Kepler* targets (and future followup of *TESS* targets) and in laying the groundwork for the next generation of planet detection and characterization missions.

Sharon is widely seen as a top graduate student in our program, and there is no doubt that her future as a leader in astronomy both professionally and scientifically is very bright.

We at Penn State know how lucky we are to have Sharon working with us for her graduate work, and she will make outstanding use of an NESSF fellowship.



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