Announcing the final examination of Patricio Cubillos for the degree of Doctor of Philosophy in Physics

Date: August 27th, 2015
Time: 1:00 PM
Room: PSB 161

Dissertation Title: Characterizing Exoplanet Atmsopheres: From Light-curve Observations to Radiative-transfer Modeling

Multi-wavelength transit and secondary-eclipse light-curve observations are some of the most powerful techniques to probe the thermo-chemical properties of exoplanets. Although the large planet-to-star brightness contrast and few available spectral bands produce data with low signal-to-noise ratios, a Bayesian approach can robustly reveal what constraints we can set, without over-interpreting the data. Here I performed an end-to-end analysis of transiting exoplanet data. I analyzed space-telescope data for three planets to characterize their atmospheres and refine their orbits, investigated correlated noise estimators, and contributed to the development of the respective data-analysis pipelines.
Chapters 2 and 3 describe the Photometry for Orbits, Eclipses and Transits (POET) pipeline to model Spitzer Space Telescope light curves. I analyzed secondary-eclipse observations of the Jupiter-sized planets WASP-8b and TrES-1, determining their day-side thermal emission in the infrared spectrum. The emission data of WASP-8b indicated no thermal inversion, and an anomalously high 3.6 micron brightness. Standard solar-abundance models, with or without a thermal inversion, can fit the thermal emission from TrES-1 well.
Chapter 4 describes the most commonly used correlated-noise estimators for exoplanet light-curve modeling, and assesses their applicability and limitations to estimate parameters uncertainties. I show that the residual-permutation method is unsound for estimating parameter uncertainties. The time-averaging and the wavelet-based likelihood methods improve the uncertainty estimations, being within 20 -- 50% of the expected value.
Chapter 5 describes the open-source Bayesian Atmospheric Radiative Transfer (BART) code to characterize exoplanet atmospheres. BART combines a thermochemical-equilibrium code, a one-dimensional line-by-line radiative-transfer code, and the Multi-core Markov-chain Monte Carlo statistical module to constrains the atmospheric temperature and chemical-abundance profiles of exoplanets. I applied the BART code to the Hubble and Spitzer Space Telescope transit observations of the Neptune-sized planet HAT-P-11b. BART finds an atmosphere enhanced in heavy elements, constraining the water abundance to ~100 times that of the solar abundance.

Major: Physics

Educational Career:
M.S. in Astronomy, Universidad de Chile, 2011 B.S. in Astronomy, Universidad de Chile, 2006

Committee in Charge:
Dr. Joseph Harrington (Chair)
Dr. Humberto Campins
Dr. Eduardo Mucciolo
Dr. Jonathan Fortney (External Committee Member)

Approved for distribution by Dr. Joseph Harrington, Committee Chair, on August, 20th, 2015.

The public is welcome to attend.