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RESEARCH EXPERIENCE AND INTERESTS

General Research Interests and Objectives

I am interested in research related to present and future astronomical and cosmological surveys and related astrophysics and cosmology projects that allow us to probe the nature of dark energy and dark matter, as well as in the utilization and development of associated data analysis, statistical, mining, reduction, and processing algorithms, methods, and techniques in many areas of physics/astrophysics, cosmology, planetary science, space science, and atmospheric science.

More broadly, I am interested in the utilization and development of modeling, data science, data analysis, statistical, mining, reduction, and processing algorithms (including image processing), methods, and techniques in a wide range of possible scientific and engineering disciplines, including physics, space and earth sciences, life sciences, and astrophysics.

Atmospheric Modeling and Analysis

02/2012-02/2014

University of California, Berkeley, Department of Earth and Planetary Science

Supervisor: Professor Inez Fung

Postdoctoral Scholar-Employee. Research focuses on mesoscale and regional (forward or "bottom-up") atmospheric transport modeling and analysis of anthropogenic and biogenic carbon dioxide emissions from northern California for multi-scale estimation and quantification of atmospheric CO2 concentrations. This work has included extensive use of the Weather Research & Forecasting Model (written mostly in **FORTRAN**), the WRF-Chem coupled weather-air quality model for atmospheric transport simulations, and the Vegetation Photosynthesis and Respiration Model (WRF-VPRM) biospheric model to simulate CO2 biosphere fluxes and atmospheric CO2 concentrations. One area of of focus of this work was to study and gain a better understanding of what effect diurnal varying/cycled CO_2 fluxes had on simulated CO_2 concentrations as compared to time-invariant CO_2 flux emissions.

I also installed, compiled, built, and configured WRF, WRF-Chem, and VPRM on a NERSC multi-core **supercomputing** system and submitted batch job scripts to this system to run the WRF model simulations. In addition to the use of WRF, this work also involved the use of the **R** statistical scripting language, the NCAR Command Language (**NCL**), **Matlab, Python**, and **Ferret** (http://ferret.pmel.noaa.gov/Ferret/home) for additional pre-processing, post-processing, modification, and visualization of **netCDF** files.

Square Kilometer Array processing and development

02/2009-02/2012

National Center for Supercomputing Applications, University of Illinois Urbana-Champaign

Supervisor: Professor Athol Kemball.

Postdoctoral Research Associate. Research and development in Square Kilometer Array calibration and processing algorithms and computing with a focus on cost and feasibility studies of radio imaging algorithms (involving extensive use of **Python** and **C++)** and issues relating to image fidelity, dynamic range**,** image statistics, and direction-dependent calibration errors with the Technology Development Project (TDP) Calibration Processing Group (CPG) at UIUC (http://rai.ncsa.uiuc.edu/SKA/RAI_Projects_SKA_CPG.html). This work has included an evaluation of the computational costs of non-deconvolved images of a number of existing radio interferometry algorithms used to deal with non-coplanar baselines in wide-field radio interferometry (Memo: "Computational Costs of Radio Imaging Algorithms Dealing with the Non-Coplanar Baselines Effect: I" with A. Kemball (http://www.astro.kemball.net/Publish/files/ska_tdp_memos/cpg_memo3_v1.1.pdf)) [1]. My work with the SKA project has also involved extensive use of **Python** and **C++** and the use and implementation of numerical and imaging simulations in conjunction with the use of the **Meqtrees** software package (http://www.astron.nl/meqwiki) and the **CASA** software package to address cost and feasibility issues related to calibration and processing for SKA and the dependence of these issues on certain key antenna and feed design parameters such as sidelobe level and mount type. Numerical simulations have included Monte Carlo simulations (written in Python) to test equations derived in [2].

Potential future complementary and supplementary work could include carrying out a radio imaging statistics analysis project in which (for example) Portable Batch System batch job scripts are to be submitted to Linux cluster systems, and which may include the following tasks:

(1) generating a simulated radio image separately with each computing node,
(2) corrupting each image with particular analytical gain error models described in [2],
(3) distributing Monte Carlo or bootstrap samples across unique hosts,
(4) computing statistics for each simulated image, and
(5) computing final statistics for all images.

The eventual goal of such a project would be to calibrate the relation between how the gain errors (i.e., amplitude, phase, pointing, and beam-width errors) translate into r.m.s. errors, and to verify corresponding analytical dynamic range expressions derived in [2]. This work would involve batch job scheduling on Linux clusters and utilizing and implementing (parallelized) C++ MPI code.

Dark Energy Research

05/2006 – 12/2008

University of California, Davis

Supervisor: Professor Andreas Albrecht

Research Assistant. I carried out a Markov Chain Monte Carlo analysis and exploration of a quintessence dark energy model (with use of **Matlab**) under the direction of Prof. Andreas Albrecht. I also wrote, modified and submitted batch job scripts to run Matlab MCMC code on a Linux computing cluster. Published Paper: "Exploring Parameter Constraints on Quintessential Dark Energy: the Inverse Power Law Model," with B. Bozek, A. Albrecht, A. Abrahamse, and M. Barnard [3].

MACHO research project

01/2004 – 01/2006

University of California, Davis / Lawrence Livermore National Laboratory

Supervisor: Dr. Kem Cook, LLNL

Research Assistant and Participating Guest. I engaged in a research project with Dr. Kem Cook at LLNL that expands and extends the work of [4] and involved the utilization and development of reddening models, star formation histories, color magnitude diagrams (CMDs), and microlensing population models of the Large Magellanic Cloud (LMC) to constrain the locations of micro-lensing source stars and micro-lensing objects (MACHOs) in the LMC and the Milky Way (MW) halo using data of 13 microlensing source stars obtained by the MACHO collaboration with the Hubble Space Telescope. We attempted to distinguish between source stars drawn from the average population of the LMC and source stars drawn from a population behind the LMC by examining the HST CMD of microlensing source stars and comparing it to the average LMC population. We carried out a 2-dimensional Kolmogorov-Smirnoff (KS) test to quantify the probability that the observed microlensing source stars are drawn from a specific model population. The 13 event KS-test analysis results rule out a model in which the source stars all belong to some background population at a confidence level of 99%. The results of the KS test analysis, taken together with external constraints, also suggested that the most likely explanation is that the lens population comes mainly from the MW halo and the source stars are located in the LMC disk and/or bar. The strength of this analysis was severely limited by the number of microlensing events used, but other ongoing microlensing surveys and projects could provide a sufficient sample of microlensing events over the next few years. The technique outlined here could prove a powerful method for locating source stars and lenses with the use of these future data sets.

Past (and potential future) work has also included a more sophisticated analysis of the MACHO source stars in relation to the general LMC population by deriving the underlying un-reddened stellar CMD and then constructing various reddening models involving uniform reddening as well as Poisson reddening models with a Poisson distribution of "cloudlets" (to make a detailed study of the effect of patchiness on the significance of the KS test) for the populations supplying the microlensing source stars, and, thus, recreating any populations that we are interested in testing. We can then compare these reddened model CMDs and the observed source star CMDs and the microlensing source stars and use the 2-

dimesional KS test to determine what model fits the data best. In this way, we can use the data to test whether the null hypothesis that the population of microlensing source stars came from the "normal" CMD fits the data better than if the source stars came from some other "background" distribution of stars. The synthetic CMD algorithm "StarFISH" [5] has been used to generate non-reddened model CMDs. Potential future work could involve the use of other synthetic CMD algorithms and/or updated theoretical isochrones.

Computational Physics Research project - extrasolar planets and habitable zones

01/2003 - 05/2003

University of California, Davis

Supervisor: Professor John Rundle

For the final project in a graduate level computational physics course instructed by Professor Rundle, I wrote computer code in **Fortran** and **IDL** (available upon request) briefly described as follows: The program computes a closed orbital ellipse of an extrasolar planet orbiting a single star using data input by the user. The program queries the user to enter various orbital and physical parameters of the planet-star system and uses this data to calculate the observed effective equilibrium blackbody temperature of the planet for a given orbital phase. The program also calculates the planet-to-star flux ratios at given orbital phases. Plots are also generated showing the shape and size of the orbit, orbital speed vs. orbital phase, planet temperature vs. orbital phase, and planet-to-star flux ratios vs. orbital phase. Finally, the code also gives an indication as to whether the inputs entered meet the criteria for a habitable planet.

TEXES data processing

09/2002-05/2003

University of California, Davis

Supervisor: Dr. Matt Richter

Research Assistant. I assisted Dr. Richter in processing data of spectra of stars and circumstellar material obtained by the Texas Echelon Cross Echelle Spectrograph (TEXES) for the mid-infrared used with the NASA Infrared Telescope Facility. Data extraction and processing was carried out using **Fortran**. Spectra were displayed using **IDL**. The project focused on finding water and OH absorption features in the spectra (e.g., flux vs. wave number) of nearby stars possessing possible circumstellar disks. Water absorption features in the Earth's atmosphere were taken into account.

HST Data Analysis

01/1999-06/1999

Department of Physics and Astronomy, San Francisco State University, CA

Supervisor: Dr. Adrienne Cool

Student Project. Engaged in laboratory project for an astronomy lab course instructed by Dr. Adrienne Cool in which possible cataclysmic variable star candidates were identified in Hubble Space Telescope images of the globular star cluster NGC 6397 using **IRAF** and SAOTNG software packages. Also carried out observational project on variable stars for this course using a 10-inch Epoch Telescope-CCD system and the IRAF and SAOTNG software packages.

References

[1] **M. Yashar** and A. Kemball, "Computational Costs of Radio Imaging Algorithms Dealing with the Non-Coplanar Baselines Effect: I",2010, TDP Calibration and Processing Group Memo 3, http://rai.ncsa.uiuc.edu/SKA/CPG_Memos.html

[2] A. Kemball, T. Cornwell, and **M. Yashar** "Calibration and Processing Constraints on Antenna and Feed Designs for the SKA: I", TDP Calibration and Processing Group Memo 4, 2009, http://rai.ncsa.uiuc.edu/SKA/CPG_Memos.html

[3] **M. Yashar** et al., Phys. Rev. D, **79**, 103004 (2009).

[4] C. Alcock et al. , ApJ, 552, 582 (2001).

[5] J. Harris and D. Zaritsky, ApJS, 136,25 (2001).

Statement of Research Interests (UC Davis)

Mark Yashar

(January, 2009)

Recent measurements of the apparent magnitude-redshift relation of type Ia supernova (Sne Ia), as well as the analysis of fluctuations of the cosmic microwave background (CMB), combined with observations of galaxy clusters and measurements of light element abundances have now placed us in an era of “precision cosmology” in which the basic components of the universe have become fairly clear. These results indicate that about 25% of the universe is composed of non-baryonic dark matter, which is not visible to us, while 4-5% consists of normal baryonic matter, both visible and invisible, and the remaining 70% of the universe is believed to be comprised of a mysterious dark energy which pervades space with negative pressure and causes the expansion of the universe to accelerate. I have had the opportunity to be involved with research projects involving both dark energy and baryonic dark matter (MACHOs).

Dark Energy

Due to a great deal of confusion in the theoretical domain, the field of cosmic acceleration (i.e., dark energy) is highly data driven at this stage, and there are a number of exciting new and proposed observational programs that could have a great impact on the field. As a graduate student, I worked on a research project with Professor Andreas Albrecht's research group that involved an MCMC analysis of a dark energy quintessence model (known as the Inverse Power Law (IPL) or Ratra-Peebles model [1,2,3]) that included the utilization of Dark Energy Task Force data models that simulated current and future data sets from such new and proposed observational programs [4]. Following the approach taken by the DETF we generated “data models” for future SNe Ia, BAO, weak gravitational lensing, and CMB observations as a representation of future dark energy experiments. We generated simulated data sets for a Lambda-CDM background cosmology as well as a case where the dark energy was provided by a specific IPL model. Following the approach taken by [5,6,7], we then used an MCMC algorithm to map the likelihood around each fiducial model via a Markov chain of points in parameter space, starting with the fiducial model and moving to a succession of random points in space using a Metropolis-Hastings stepping algorithm. From the associated likelihood contours, we found that the respective increase in constraining power with higher quality data sets produced by our analysis gave results that were broadly consistent with the DETF for the dark energy parameterization that they used. We also found, consistent with the findings of [5,6,7], that for a universe containing dark energy described by the IPL potential, a cosmological constant can be excluded by high quality “Stage 4” experiments by well over 3 sigma. Out results were published in Physical Review D [8].

Possible future work and related research interests

- Carrying out a similar MCMC analysis on other scalar field dark energy quintessence

  models, such as the SUGRA [9] model, which is considered to be a more realistic model than the IPL model from a particle physics standpoint in that it includes supergravity radiative corrections to the IPL model. The SUGRA model is also considered to be a better "tracker" and has a larger basin of attraction than the IPL model, and suffers less from fine-tuning problems than does the IPL model [10].

- Execute an MCMC analysis with DETF or other galaxy cluster data models in addition to SNe Ia, WL, BAO, and CMB data models

- Perform the MCMC analysis with improved systematic error estimates including photometric redshift biases for the simulated weak lensing data sets.

- Considering the impact of including cross correlations among different photometric data types (which many expect to lead to significant improvements over DETF projections) when carrying out MCMC analysis of quintessence models.

- An MCMC analysis that focuses on the impact of future experiments on non-DE cosmological parameters (e.g., parameters that do not make up the expression for the scalar field potential) such as matter density and curvature.

- Using this MCMC analysis approach to assess how the different *individual* simulated data sets (such as WL data alone or BAO data alone), rather than combined data sets, constrain dark energy models differently.

- Work towards a better understanding of differences between constraints placed on dark energy parameters from Stage 4 space-based data and Stage 4 ground-based data.

- Gain a better understanding of whether different types of observations (e.g., SNe Ia, WL, BAO, CMB) are more or less constraining for different dark energy models.

- Apply the eigenmode analysis work of [11] for comparing different quintessence models to a larger number of different quintessence models.

- Employ the eigenmode analysis work of [11] to differentiate between the tracking and non-tracking (e.g., transient) regions of parameter space for tracker quintessence models such as the IPL, Albrecht-Skordis, and SUGRA models.

Constraining the Locations of Microlenses Towards the LMC

Prior to the dark energy project described above, I engaged in a research project with Dr. Kem Cook that expands and extends the work of [12] and involved the utilization and development of reddening models, star formation histories, color magnitude diagrams (CMDs), and microlensing population models of the Large Magellanic cloud to constrain the locations of micro-lensing source stars and micro-lensing objects (MACHOs) in the Large Magellanic Cloud (LMC) and the Milky Way halo using data of 13 microlensing source stars obtained by the MACHO collaboration with the Hubble Space Telescope. We attempted to distinguish between source stars drawn from the average population of the LMC and source stars drawn from a population behind the LMC by examining the HST CMD of microlensing source stars and comparing it to the average LMC population. We carried out a 2-dimensional Kolmogorov-Smirnoff (KS) test to quantify the probability that the observed microlensing source stars are drawn from a specific model population. The 13 event KS-test analysis results rule out a model in which the source stars all belong to some background population at a confidence level of 99%. The results of the KS test analysis, taken together with external constraints, also suggested that the most likely explanation is that the lens population comes mainly from the MW halo and the source stars are located in the LMC disk and/or bar. The strength of this analysis was severely limited by the number of microlensing events used, but other ongoing microlensing surveys and projects could provide a sufficient sample of microlensing events over the next few years. The technique outlined here could prove a powerful method for locating source stars and lenses with the use of these future data sets.

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References

[1] B. Ratra and P. J. E. Peebles, Phys. Rev. D **37,** 3406 (1988).
[2] P. J. E. Peebles and B. Ratra, Astrophys. J. **325**, L17 (1988).
[3] P. J. E. Peebles and B. Ratra, Rev. Mod. Phys. **75**, 559 (2003).
[4] A. Albrecht et al. (2006), astro-ph/0609591.
[5] M. Barnard et al., Phys. Rev. D **77**, 103502 (2008).
[6] B. Bozek et al., Phys. Rev. D **77**, 103504 (2008)
[7] A. Abrahamse et al., Phys. Rev. D **77**, 103503 (2008).
[8] **M. Yashar** et al., Physical Review D, **79**, 103004 (2009).
[9] P. Brax and J. Martin, Phys. Rev. D **61**, 103502 (2000).
[10] S. Bludman, Phys. Rev. D **69**, 122002 (2004).
[11] M. Barnard et al. , Phys. Rev. D **78,** 043528 (2008).
[12] C. Alcock et al. , ApJ, 552, 582 (2001).
[13] J. Harris and D. Zaritsky, ApJS, 136,25 (2001).