

New Mexico NASA EPSCoR Year 1 Progress Report

Project Title: New Mexico Exoplanet Spectroscopic Survey Instrument (NESSI)
Grant Number: NNX09AP69A
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PI Institution: New Mexico Institute of Mining and Technology (NMT)
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1. Research accomplishments measured against the proposed goals and objectives

Research Accomplishments: The NESSI project started conceptual design work prior to the inception of the NASA EPSCoR funding, based principally on the need for the instrumentation for this new approach in the exoplanet characterization community and a facility instrument for NMT's 2.4m telescope at the Magdalena Ridge Observatory. EPSCoR funding for the project was released within NMT in Sept. 2009. Work to identify student and postdoctoral personnel for the project began at that time, along with a much more concerted effort in defining instrument capabilities and instrumental design by the NMT and NASA-JPL teams. This work included telecons and in-person meetings of the distributed team in Socorro, NM and Pasadena, CA. The design work culminated in a design review of the conceptual choices and optical layout of the NESSI system at JPL, on March 15, 2010. The reviewers for the design were: Dr. Mark Colavita (JPL, TMT and Keck Interferometer) and Dr. Nick Konidaris (Caltech, MOSFIRE team) (both external to NESSI project), Dr. Gautam Vasisht (JPL) and Dr. Mark Swain (JPL) (both NASA partners on the NESSI project). Design documents presented for that review are attached. The review was successful, with only minor suggestions for consideration during tolerancing and for final analysis and design of the mechanical system. Ongoing work following the design review has been conducted by Dr. Colby Jurgenson (NMT-MRO), Dr. Kamel Houairi (NMT, NESSI postdoc), Dr. Fernando Santoro (lead Mechanical Engineer for MRO-Interferometer, NMT) to define and design the mechanical system and telescope interfaces. Further, a team of student researchers has been developed and we are defining the operational and software-hardware interfaces for NESSI and developing the expertise to build a data reduction pipeline for the NESSI data stream on exoplanet targets. This student team includes graduate students: Heather Bloemhard, Luke Schmidt, John Russell, and undergraduate students Dan Rodeheffer and Charlie Moore. Progress is tracked via weekly team meetings with the Science PI. A simple website has been developed about the project on the PI's homepage (<http://www.physics.nmt.edu/~mce>) and will be augmented as design documents become available. The opto-mechanical design for NESSI is expected to be completed by July, 2010 with the software design review set for August, 2010. We are working toward a first light goal for NESSI of February, 2011.

Personnel: Due to the timing of the inception of funding at NMT, it was not possible to hire graduate students for the fall 2009 semester. Currently we have 3 graduate and 2 undergraduate students participating actively on project (see below), and recently hired and lost a postdoc, whose post we are in the process of re-advertising. We have been approached by several other students interested in the science we will do with NESSI, and will likely have to become more creative in terms of engaging them as it will not be possible with the EPSCoR budget in hand to pay all of them to work on NESSI full time.

Funding: Current estimates for the hardware for NESSI place the cost at approximately \$850,000. This leaves some contingent internal NMT funding from that pledged by the NMT Vice-President. The majority of this funding will be centered around paying for the detector array and electronics, optics and cryogenic dewar (roughly \$650,000). An expense account has been established, quotes are being gathered and a procurement strategy has been discussed with the head of procurement at MRO for how to proceed most expeditiously on this stage of the process. EPSCoR funding to expense ratio is behind due to the timeline on hiring students associated with the project.

Goals for the coming year(s): Presently having completed slightly less than 0.75 year on the NESSI project, and with the funding being disjoint from the academic year, lack of adequate personnel effort on the project has put us behind compared to our original schedule. We are intending to make up this work during the 2010 summer as we are now fully staffed with students with respect to the original EPSCoR proposal intentions. The goal of first light of NESSI by Feb. 2011 places us approximately 4 months behind the original schedule submitted in the 2009 proposal. Along with completing final design and beginning procurement for NESSI components as our major goals for Year 2, we plan to organize and hold the first Tiger Team workshop (to coincide with first light of NESSI) and to develop collaborations with other universities in NM to allow access for NM students to NESSI once operations have been established. Other goals include giving more talks about the project and submitting further funding and observing proposals to develop the community and support students in activities associated with the project. In year 3, we will conduct routine science observations with NESSI, hold the second Tiger Team workshop, begin publishing refereed papers on NESSI science, and conduct observations with students from around NM on a wide range of science topics.

Collaborations: No new collaborations outside of the original one between NASA-JPL and NMT-MRO have been established so far in year 1, but this is listed as a series of activities associated with establishing the Tiger Team and student observing fellowships for years two and three as NESSI becomes operational, so we anticipate this will change soon. Further, information gleaned from the development of NESSI, once operational, is expected to be brought back to several classes at NMT in the Physics, Astronomy and the new Geobiology program, including a class in Astrobiology which is team taught by Dr.'s Boston and Creech-Eakman and is expected to be taught during year 2 of the grant period.

2. Research success

Several talks about NESSI and papers associated with NESSI's proof of concept have been delivered/published in the last year (see addendum below), including talks on the NMT campus, at American Astronomical Society Meetings, and Astrobiology Science Conference Meetings,

via press releases, and during tours of the Magdalena Ridge Observatory for Senator Bingaman and his staff. The seminal paper, by the JPL contingent of the NESSI team, proving that ground-based spectroscopy of extrasolar planets was feasible (using NASA's IRTF telescope) and could yield new scientific insights, was published in Nature on February 4, 2010. A presentation on the full design of NESSI and an associated paper detailing that design has been accepted for the SPIE conference in San Diego in June, 2010. Two students associated with the project (Bloemhard and Russell) have begun learning the detailed data-reduction steps used for the Nature paper through weekly interactions via telecon and email with the NASA JPL team (training on the IRTF data in the Nature paper) to develop and prepare a data reduction pipeline for when data becomes available through NESSI. We are investigating sending these two students this summer to work directly with the JPL team to learn new data reduction techniques and/or attend telescope runs to gather and help reduce more data as it becomes available. This activity has resulted in submission of a telescope observing proposal to the IRTF for follow-on spectroscopic observations of another exoplanet candidate, which we are awaiting to hear the results for. Further, an internal JPL DRDF proposal for \$100,000 was submitted to support the NESSI team and help further collaboration via travel and support of engineering staff at JPL, however the proposal was unsuccessful. We are intending to submit Education and Outreach proposals this summer to an NSF and a NASA call aligned with the goals of the NESSI project and the science involved in spectroscopy of extrasolar planets. Initial planning for the Tiger Team workshop one has commenced, including discussing membership on the team with various potential members of the scientific community within and outside New Mexico and at other NASA centers, and an initial approach has been made to LANL's Institute for Advanced Study to see if they would be interested in participating in the workshop. Because commitments are not in place yet, we will not list these in the spreadsheet at this time.

Talks/Posters/Press Releases:

- Press Release, NMT, Aug 3, 2009, "Tech Secures Funding to Examine Exoplanets"
- Creech-Eakman, M. "NESSI and the Path to Discover the True Nature of Extrasolar Planets", Joint colloquium talk, Earth and Environmental Sciences and Physics Depts., NMT, Dec, 2009.
- Creech-Eakman, M. et al. "The New Mexico Tech Extrasolar Spectroscopic Survey Instrument (NESSI)", Jan, 2010, American Astronomical Society Meeting, talk.
- Houairi, K. et al. "NESSI: The New Mexico Tech Extrasolar Spectroscopic Survey Instrument", Jan, 2010, New Mexico Symposium, Poster.
- Press Release, NMT, Feb 9, 2010, "New Exoplanet Research Shines Light on Tech Project"
- Creech-Eakman, M., presentation to Senator Bingaman and his staff at Magdalena Ridge Observatory Interferometer and discussions of NESSI, Feb 19, 2010.
- Swain, M., March 9, 2010, JPL, "The presence of methane in the atmosphere of an extrasolar planet", colloquium talk.
- Swain, M., March 11, 2010, Univ. of AZ, LPL, "Probing exoplanet atmospheres with molecular spectroscopy", colloquium talk.
- Boston, P. et al. "Exoplanets: Not Just Dots in the Sky Anymore", March, 2010, Astrobiology Science Conference (AbSciCon), talk.

- Jurgenson, C. et al “NESSI: The New Mexico Tech extrasolar spectroscopic survey instrument”, to be given, June, 2010, SPIE, Astronomical Instrumentation, San Diego, CA., talk.

Reviews:

- Design review, NESSI requirements and optical design, JPL, 1:00-4:00 pm, March 15, 2010. Presenters: Creech-Eakman, Jurgenson and Houairi; Reviewers: Colavita, Konidaris, Swain and Vasisht.

Papers:

- Swain, M. et al. “A ground-based near-infrared emission spectrum of the exoplanet HD189733b”, Feb, 2010, Nature, 463, 637.
- Jurgenson, C. et al “NESSI: The New Mexico Tech extrasolar spectroscopic survey instrument”, accepted associated with talk, June, 2010, SPIE Proceedings, 7735-44, San Diego, CA.

Proposals:

- Telescope proposal, NASA, IRTF, SpeX Instrument, “Spectroscopic Observations of Transiting Exoplanet WASP-1b”, PI: Bloemhard, submitted March 30, 2010, pending.
- Funding proposal, JPL internal Director’s Research and Development Fund (DRDF) Proposal, FY2010, “NESSI – the New Mexico Exoplanet Spectroscopic Survey Instrument”, PI: Swain, institutional co-I: Creech-Eakman, Nov. 9, 2009, \$100,000, denied.

3. Demographic information on participants

- Faculty: 6 male, 2 female, no underrepresented minorities
- Post-Doc: 1 male, no underrepresented minorities
- Graduate Students: 2 male, 1 female, no underrepresented minorities
- Undergraduate Students: 2 male, no underrepresented minorities

4. Systemic change

Nothing to report at this time.

5. Examples of successful technology transfer to the private sector

Nothing to report at this time.

6. Discussion of interaction and cooperation with New Mexico Space Grant Consortium

Research team attended the annual meeting and reported on update of research.