DDF annual report

Title of Investigation:

Closure Phases and Novel Architectures for the Interferometer Version of the Terrestrial PlanetFinder Mission

Principal Investigator:

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Other In-house Members of Team:

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Other External Collaborators:

Dr. J. Rajagopal (Goddard Space Flight Center/University of Maryland Michelson Fellow) and Dr. J. Richardson (NRC Fellow)

Initiation Year:

FY 2005

Aggregate Amount of Funding Authorized in FY 2004 and Earlier Years:

$0

Funding Authorized for FY 2005:

$9,000, 0.3 FTE

Actual or Expected Expenditure of FY 2005 Funding:

$9,000

Status of Investigation at End of FY 2005:

To be determined

Expected Completion Date:

Initial studies were completed in November 2005, and a paper has been submitted to the *Astrophysical Journal* entitled, "The Importance of Phase in Nulling Interferometry and a Three Telescope Closure-Phase Nulling Interferometer Concept."

Purpose of Investigation:

The Terrestrial Planet Finder (TPF) mission is part of NASA's Exploration Vision. Currently, two TPF versions are envisioned. The 3.5m x 6m visible wavelength coronagraph, which would block light from a star so that scientists could observe possible orbiting planets and other material, is planned for a 2015 launch. The other is a mid-infrared, free-flying interferometer, which would consist of two or more telescopes that are linked together so that they would operate like one much-larger telescope. Its launch is planned for 2019–2020.

To date, most of the research into the TPF Interferometer's (TPF-I) architecture has focused on a dual-chopped Bracewell design, which is a particular version of a nulling interferometer made up of four telescopes. Nulling interferometers are analogous to coronagraphs. They combine the light from multiple telescopes so the central starlight is suppressed, allowing one to see faint emission from material around the star, including one or more planets. However, it is possible that the TPF-I mission can be accomplished with a simpler three-telescope design, which would reduce mission costs and risks. Thus, our first goal was to study possible three-telescope designs and calculate whether such configurations are useful to the TPF mission.

We also want to study whether closure-phase interferometry, which is widely used in ground-based astronomy, might be useful to the TPF-I mission. This is significant for the mission. This technique of using data from three or more telescopes in such a way that distortions should cancel improves the quality of data after it's taken. It would allow NASA to simplify the interferometer and improve robustness against path-length and amplitude errors. Thus, we investigated whether closure-phase techniques are directly applicable to the nulling interferometer.

Accomplishments to Date:

An initial investigation was completed and a paper has been submitted to the *Astrophysical Journal* entitled, "The Importance of Phase in Nulling Interferometry and a Three Telescope Closure-Phase Nulling Interferometer Concept." The results are sufficiently interesting to warrant further research.

Planned Future Work:

Dr. Danchi would like to continue research in this area and has obtained other results that could be published. He is seeking other funding opportunities to support this research.

Key Points Summary:

Project's innovative features: This project has resolved a long-standing issue regarding whether closure phases exist and can be measured for nulling interferometers. The research has allowed us to establish the deep connection between nulling and conventional interferometers. The literature on nulling interferometry has a number of conceptual errors that have hindered progress in this field. We are in the process of correcting some of these errors, and the paper mentioned above is our first effort in this direction.

Potential payoff to Goddard/NASA: It is important that NASA base the TPF-I mission on a sound theoretical and conceptual footing, given the project's cost and potential consequences to science. Our research has addressed some of the deficiencies in the previous work and has led to

new insights into the physics of the nulling interferometer. We propose a new and simpler architecture that is free from some of the known problems with previously proposed architectures.

The criteria for success: Our criteria were that we could arrive at a publishable result. We already have written one paper and are preparing another.

Technical risk factors: The principal problem with the DDF program, like the IRAD program, is that it is under-funded. Also, there is no carry-over between fiscal years. This means that if you obtain a good result late in the fiscal year, then you are forced to write and publish papers and results from your DDF program with other funds. This is in apparent conflict with the requirement of full-cost accounting, as the DDF program is thus getting a free ride from other programs.