

Challenger Center for Space Science Education
Department of Space Science Research
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This report addresses scientific research and science education and public outreach efforts conducted within the Department of Space Science Research of Challenger Center for Space Science Education, headquartered in Alexandria, Virginia. The period covered by this report is November 1, 2002 through October 31, 2003.

1. FOREWORD

Challenger Center for Space Science Education is a global not-for-profit organization created in 1986 by the families of the crew of the space shuttle *Challenger*, STS 51-L, to carry out the science and mathematics education mission of that flight. Challenger Center's most visible activity in pursuit of this goal is the network of Challenger Learning Centers (forty-eight at writing) in the United States, Canada, and the United Kingdom, in which student crews man a simulated mission-control center and a simulated spacecraft to experience an adventure in collaborative learning about space flight and the space environment. Challenger Center is responsible for a range of classroom products, and for education and public outreach programs of national scope, including *Journey through the Universe*, space flight mission-related E&PO services (presently supporting the MESSENGER mission to Mercury), a speakers' bureau, an International Faculty of space science educators, and teacher-training programs. Challenger Center is the lead organization (with the Smithsonian Institution and NASA) in the *Voyage* scale-model solar system exhibition on the National Mall in Washington, DC, and is responsible for associated educational materials and for supporting replication of the model at other sites.

The Department of Space Science Research (SSR) was created within Challenger Center in 1998 to make a home for practicing scientists engaged in active scholarly research who also have the desire to contribute to public knowledge and understanding of science. Challenger Center staff scientists are engaged in observational and theoretical astronomical investigations using ground- and space-based facilities, working on-site, in the field, and with collaborators at other institutions. SSR staff are responsible for ensuring the highest level of scientific accuracy in all Challenger Center products. SSR scientists and educators are actively engaged in education and public outreach activities through: collaboration in the preparation and production of curricular materials; leading educator workshops on Challenger Center-developed curricular materials; visiting classrooms; and the presentation of Family Science Night programs at the National Air and Space Museum and other venues.

2. PERSONNEL

2.1 Present Staff

The professional staff of the Department of Space Science Research, and their research interests, consists of

- Jeffrey J. (Jeff) Goldstein, Vice President for Space Science Research (Ph.D. University of Pennsylvania, 1989) — *Planetary atmospheric dynamics and structure; infrared heterodyne spectroscopy*.
- Timothy A. (Tim) Livengood, Staff Researcher, Astrophysics (Ph.D. The Johns Hopkins University, 1992) — *Composition and structure of planetary atmospheres, planetary aurorae, infrared and ultraviolet remote-sensing of planetary systems*.
- Harri A. T. Vanhala, Staff Researcher, Astrophysics (Ph.D. University of Oulu, 1997) — *Stellar and planetary formation processes*.

SSR staff also include personnel with specific responsibilities to support education and public outreach programs of the department.

2.2 Changes in 2002–2003

Total department staff now number ten, after the departure of three members of the professional staff in the past year:

- Dr. Mary L. Radnofsky left the department in January to take a teaching position in the Republic of China.
- Dr. Agnes Pasco Conaty left the department in June.
- Dr. Matt Bobrowsky left the department in September to take a position as an outreach scientist at the Space Telescope Science Institute.

3. FACILITIES

Challenger Center owns and occupies a building at Pitt Street Centre in Alexandria, Virginia. The Department of Space Science Research resides on the third floor. On-site facilities include the Challenger Learning Center of Greater Washington and the EdVenture Lab, a prototype “smart-classroom” facility with multimedia capabilities for seminars, educator training, and other presentations. Additional space is available for future expansion and for possible optics laboratory facilities.

4. RESEARCH ACTIVITIES

4.1 Planetary Atmospheres

T. A. Livengood investigates chemical abundances, thermal profiles, and dynamics in planetary atmospheres, in collaboration with Th. Kostiuik and colleagues at NASA's Goddard Space Flight Center (GSFC), and with T. Hewagama at the University of Maryland, College Park, using GSFC's Heterodyne Instrument for Planetary Winds and Composition (HIPWAC). In 2003, Livengood reported at the AAS Division for Planetary Sciences meeting on observations of the meridional distribution of nonthermal emission by CO₂ in the upper atmosphere of Mars, and co-authored reports on measurements of the meridional concentration of ozone in

Mars' atmosphere and on seasonal variability of the thermal structure and hydrocarbon concentration in the atmosphere of Saturn. These projects support the Mars Global Surveyor mission and the continued exploration of Mars by *in situ* spacecraft, and support the *Cassini* mission to the Saturn system. Ground-based observations accomplished during this year include measurements of ethane emission from Jupiter's auroral regions; spectroscopy of ozone emission from the atmosphere of Mars; spectroscopy of ozone signatures in the Earth's atmosphere; observations of the meridional concentration of CO₂ non-thermal emission on Mars (led by Livengood); and preliminary observations seeking to detect the presence of ethane in the stratosphere of Uranus (led by Livengood; results inconclusive).

J. Goldstein is collaborating with F. Schmüling (First Physical Institute, Universität zu Köln) in the study of atmospheric dynamics on Venus and the subsolar-to-antisolar flow. Livengood and Goldstein together are collaborating with Th. Kostiuk in research on the wind direction and magnitude of zonal flow in the equatorial region of Saturn's moon, Titan. The zonal flow velocity is measured by comparison of ethane spectral line frequencies at Titan's East limb vs. the West limb, retrieving a present value of 210 ± 150 m/s. Observations are planned for December 2003 at the National Astronomical Observatory of Japan's Subaru 8m telescope facility to pursue significantly improved measurements.

T. A. Livengood's research effort is supported by a Cooperative Agreement between Challenger Center and Goddard Space Flight Center. J. Goldstein's research effort is supported by Challenger Center operating funds.

4.2 Star Formation

H. A. T. Vanhala is investigating the hypothesis of the triggered origin of the solar system — the idea that the formation of the solar system was initiated when an interstellar shock wave propagating from a nearby explosive stellar event impacted on a molecular cloud core from which the solar system was formed. This research has been conducted in collaboration with A. P. Boss (Carnegie Institution of Washington). An appreciable fraction of radioactive isotopes carried by the shock wave could have been injected into the forming solar system, in this manner leaving a record of the event in meteoritic material. Calculations reveal that the distribution of radioactive species in the early solar system could have been spatially or temporally heterogeneous.

4.3 Late Stages of Stellar Evolution and Planetary Nebulae

H. A. T. Vanhala, with S. G. Starrfield (Arizona State University) and W. R. Hix (University of Tennessee / Oak Ridge National Laboratory), has continued the development of a numerical simulation code to investigate classical nova outbursts. Calculations carried out with the code are expected to answer open questions about thermonuclear run-aways in the accreted hydrogen rich envelope on the white dwarf component of a close binary system, the source of classical nova outbursts.

Before his departure from Challenger Center, M. Bobrowsky continued his investigation of the formation of planetary nebulae, using imaging and spectroscopic studies of proto-planetary nebulae. Bobrowsky collaborated with A. Riera, P. García-Lario, A. Manchado, and R. Estalella to report in *Astronomy and Astrophysics* on the proto-planetary nebula Hen 3–1475, finding that it shows a remarkable highly collimated optical jet with an S-shaped string of shock-excited knots. Extremely high velocities have been observed in the innermost regions of its jet. Bobrowsky collaborated on a report by T. B. O'Hara (U. of Illinois, Urbana-Champaign) presented at the 201st meeting of the AAS, reporting on infrared imaging observations of a detached toroidal dust shell around HD 168625. This object is a candidate Luminous Blue Variable star that apparently underwent a major mass-loss episode several hundred years ago. The morphology of the dust ring is consistent with the interaction of a fast wind with a pre-existing density contrast in the neighboring interstellar medium.

5. EDUCATION AND PUBLIC OUTREACH INITIATIVES OF SSR

The Department of Space Science Research is the lead department at Challenger Center in several education and public outreach (E&PO) efforts of local and of national scope.

5.1 Journey through the Universe

Four "Journey Weeks" have been held since the beginning of November 2002, in: San Diego California; Marquette and Alger Counties, Michigan; Labette County, Kansas; and in Washington, DC Public Schools and schools of the Catholic Archdiocese of Washington. A total of $\approx 26,000$ students were contacted directly by 45 scientists in nearly 600 classroom visits, including SSR staff and volunteer Visiting Researchers; teacher workshops were held in each Journey Week, preparing ≈ 400 teachers to use Challenger Center curricular materials; and ≈ 2500 students, teachers, and family members attended Family Science Night events to experience a family field trip to the frontier of space exploration.

All Journey education module components are developed by starting from the National Science Education Standards, to assure maximum compliance with local standards, and include complete lesson plans, facilitation schemes, and grading rubrics to provide for maximum utility within the classroom. In Washington, DC, annual compendia of materials have been developed tied to the DCPS content and performance standards, constituting the adopted curriculum for Earth and Space Science at the 6th grade level. Approximately 625 pages of new curricular material has been developed by scientist/instructional designer teams during the past year and will be presented in Journey Weeks planned for the coming year. *Journey through the Universe* education modules are made freely available to the public on the worldwide web through <http://www.challenger.org/teaching/community/index.html>.

The *Journey through the Universe* Annual Conference was held at the National Science Teachers Association an-

nual convention in Philadelphia, PA, in March 2003. Representatives from this past years' *Journey* communities were in attendance, as well as representatives from most of the previous five *Journey* communities.

The national *Journey through the Universe* program is supported by grants from NASA Headquarters' Office of Minority University Research and Education Programs and by NASA's Offices of Space Science, Space Flight, and Earth Science. The Washington, DC *Journey* effort is supported by contributions from District of Columbia Public Schools, from ARAMARK Corporation, and from Trinity College. J. Goldstein is the PI of the *Journey through the Universe* program.

5.2 MESSENGER Education and Public Outreach

Challenger Center is responsible for a large portion of materials development and public presentations for the E&PO component of the MESSENGER mission to Mercury. Overall direction of the MESSENGER education and public outreach effort is the responsibility of S. Stockman at NASA's Goddard Space Flight Center. H. A. T. Vanhala has been leading the development of grade 5–12 curricular materials for the first MESSENGER education module, disseminated at a workshop for MESSENGER Educator Fellows and in JttU programs. Members of the MESSENGER engineering team have participated as consultants in materials development and as visiting researchers in *Journey* Weeks, including the October 2003 Washington, DC *Journey* Week.

Much of the MESSENGER education module deployment is handled by a cadre of Educator Fellows, volunteers who have applied for and taken training with the materials and whose application includes an implementation plan to pursue venues in which to deliver workshops and public presentations to train formal and informal science educators and to directly deliver content to students and the general public. The MESSENGER Fellowship program selection was conducted in the Spring of 2003, resulting in the selection of 19 MESSENGER Educator Fellows. The Educator Fellowship workshop was held in Washington, DC in June 2003, at which the Fellows were introduced to lesson plans and facilitation training on topics such as replicating Herschel's detection of infrared radiation using a prism and thermometry, as well as exploring the properties of the space environment, with specific reference to the enabling technologies in the MESSENGER spacecraft and mission design that address its cruise and operational environment. The MESSENGER curriculum materials also were presented, in less detail, at the annual Challenger Learning Center Flight Directors' Conference in Kansas City, Missouri, in August.

The MESSENGER education modules developed so far are available freely on the world-wide web at <http://btc.montana.edu/ceres/MESSENGER/epomain.htm>. Challenger Center's participation in MESSENGER E&PO programs is supported by a contract from the Carnegie Institution of Washington.

5.3 Family Science Night at the National Air and Space Museum

Challenger Center conducts a regular series of Family Science Nights in the Lockheed-Martin IMAX theater of the National Air and Space Museum, for schools within the Washington, DC metropolitan area. This program is independent of Family Science Night events within the *Journey through the Universe* program. The FSN program consists of an after-hours tour of the central Milestones of Flight Gallery, a half-hour talk on a space science theme by a Challenger Center or volunteer scientist, and showing of an IMAX film on a related theme. During the reporting period, ten FSN events were conducted at NASM, reaching a total audience of 3620 parents, children, and teachers.

The FSN program at the National Air and Space Museum is funded by the National Space Club.

5.4 Voyage Scale Model Solar System

Voyage is a permanent open-air space science exhibition on the National Mall in Washington, DC. The *Voyage* exhibit consists of 13 stations forming a scale model solar system that accurately represents orbital distance as well as the size of the major objects in the solar system using a single scale; one of the 13 stations represents comets, asteroids, and other planetesimals in the solar system, one represents the position of *Voyager* 1 on its way out of the solar system, one represents the Sun, and one acts as an entry point to the exhibit. The entire exhibit stretches over approximately 600 yards, from the East end of the National Air and Space Museum to the Smithsonian Institution's Castle. Challenger Center is the lead organization in the *Voyage* project and has responsibility for the development and deployment of educational materials and replication of the model for installation at other sites.

Voyage was made possible by grants from the National Air and Space Administration and through the cooperation of the Smithsonian Institution.

5.5 Voyages Across the Universe Speakers' Bureau

The *Voyages Across the Universe* Speakers' Bureau was initiated in late 2002, at the beginning of the reporting period. SSR staff scientists have delivered 13 presentations to audiences in Delaware, Maryland, Ohio, Virginia, and Michigan. The audience total to date is ≈ 5500 people. Of these, 1115 were teachers, 1900 were families attending Family Science Nights in their community, and 2425 were students in their schools participating in classroom visits or in auditorium presentations.

5.6 Support for Challenger Learning Centers

The Space Science Research Department contributes to the accuracy and depth of content used in flight simulation scenarios conducted within the 48 operational Challenger Learning Centers; Challenger Center *per se* provides the content for Learning Center missions, but CLC's are other-

wise independent. Before his departure, M. Bobrowsky this year conducted a thorough review and revision of materials supporting the scenarios *Rendezvous with a CometTM* and *Rendezvous with Comet HalleyTM*, incorporating the best current scientific understanding of comets in general and of Comet Halley in particular. This revision was supported by contributions from T. A. Livengood and from H. A. T. Vanhala as well as calling upon outside experts as needed. The results of this review were presented at the annual Challenger Learning Center Flight Directors' Conference held in Kansas City, Missouri in August. SSR staff scientists additionally provided support in response to ongoing needs of the Learning Center Network, responding to questions from the

Centers and providing input to ongoing maintenance of scenario content.

PUBLICATIONS

The publication list includes all refereed papers published between November 1, 2002 and October 31, 2003 by SSR staff.

Riera, A., P. García-Lario, A. Manchado, **M. Bobrowsky** and R. Estalella, 2003, "The high-velocity outflow in the proto-planetary nebula Hen 3-1475," *Astron. and Astrophys.*, 401, 1039-1056.

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