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"Planetary Aeronomy and Related Studies"

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This grant supported a varied program of theoretical studies of planetary bodies and their atmospheres, including that of the Earth viewed globally.

Mercury atmosphere -- Sprague and Hunten, in collaboration with Katharina Lodders of Washington University, proposed, mainly on cosmochemical grounds, that S atoms are an important constituent of the atmosphere (30 times more abundant than sodium). This paper has appeared in Icarus (Sprague et al., 1995). We also suggest that condensed sulfur is an excellent candidate for the radar-bright polar caps, more plausible than water ice because the latter is only barely stable even in permanently-shadowed craters. The best prospect for detection of the vapor is through its resonance lines, a triplet near 1814 A. Mercury is too close to the Sun to be observed by any existing space telescope, but there is some prospect that the search could be made from a Shuttle-based spectrograph such as Lyle Broadfoot's UVSTAR.

Sprague and Hunten have completed an elaborate data analysis of over 100 measurements of the Na D lines, obtained with the 61-inch telescope and our echelle spectrograph. Full account has been taken of the radiative-transfer problem that arises because the Na atmosphere is not optically thin. The output of this code is used in another program that makes an elaborate inverse interpolation in two angles and optical depth and computes the effect of the seeing (always bad for Mercury). The seeing is determined by fitting cuts across a computed image to part of the spectrum adjacent to the sodium lines, and typically ranges from slightly less than 4 arcsec to worse than 6 (diameter at 1/e of a Gaussian). The final result is a list of Na abundances, with some information on spatial distribution. One particularly interesting result of further analysis is a strong abundance maximum in the morning relative to the afternoon, confirming an earlier result for potassium, based on much fewer measurements. There is no sign of correlations with solar radiation pressure or with mesures of solar activity such as sunspot number or F10.7. The analysis, completed during the extension of the present grant, is described by Sprague et al. (1997).

This work depends heavily on the Hapke parameters used to estimate the reflectance of Mercury's surface. The paper by Domingue et al. (1997) examines the credibility of the available parameters, which are derived from disk-unresolved photometry, and concludes that errors in the derived Na abundances could be as great as 30%.

Thermospheric cooling -- Recent work (by Bougher and a student) includes:
1) For Venus, the implementation of a new scheme to replace the "Rayleigh friction" parameterization pioneered in Bougher's thesis work to slow down the day-to-night winds on Venus. This new scheme generates the friction from dissipation of upward-propagating gravity waves;
2) Progress in adapting the Thermospheric General Circulation Model to Jupiter's upper atmosphere (a collaboration with Hunter Waite).

Martian water vapor -- Based on the observations of Rizk et al. (1991b), a study of meridional transport has been published by Icarus (Rizk et al., 1995). Much of this work was part of Rizk's Ph.D. dissertation. Analysis of the changes of abundance with the help of a 2D zonally symmetric water transport model strongly indicates that local sublimation and deposition are much more important than meridional transport.

Excellent observations were obtained during the latest two apparitions of Mars. A report of this work has just appeared in JGR (Sprague et al., 1996).

Shoemaker-Levy 9 IR spectra -- We are still working on our mid-IR spectra of impacts R and W taken aboard NASA's Kuiper Airborne Observatory. Sprague has taken the lead in the analysis, which is extremely complex because it uses a line-by-line spectrum synthesis program from NASA-Goddard, which was developed for Voyager IRIS data. We have published one paper on the detection of water vapor (Sprague et al., 1996).

Micrometeoroid Entry -- We have been attempting to account for the survival of unmelted micrometeorites bigger than about a tenth of a millimeter, and of smaller grains with unannealed ion tracks. Direct entry of such bodies should heat them above the melting or annealing temperatures, respectively. We have studied entry following aerocapture in the thermosphere, and have found that by this path almost a percent of all the particles incident on the Earth can survive unmelted, with a few tenths of a percent unannealed. Even larger efficiencies are found for direct entry at zenith angles approaching 90^{o}. A paper is in press in Icarus (Hunten, 1997).

Atmospheric Perturbations -- Kring et al. (1996) is a study of the probability that a large impact could generate a perturbation of stratospheric SO_2 comparable to that of a large volcanic eruption. An event comparable to Krakatau probably occurs every 10,000 years, and one that could cause a serious climatic perturbation perhaps every million years.

Reviews -- Bougher is editor-in-chief of the book Venus II, which will incorporate Magellan results and updates from the last decade of Pioneer Venus. The other editors are Hunten and Roger Phillips; publication is imminent.

Hunten (1997) is an encyclopedia article on the atmosphere of Venus. Publication has been lagging, but the publisher has recently picked it up and it should appear during 1997.

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