ATTEMPT TO OBSERVE THE SODIUM EXOSPHERE OF MERCURY DURING THE 1993 SOLAR TRANSIT: A.E. Potter, NASA Johnson Space Center, D. Talent, Lockheed Engineering and Science Co., H. Kurokawa, Hida Observatory, Japan, S. Kawakami, Osaka Museum of Science, Japan, and T.H. Morgan, Southwest Research Institute.

Introduction. High-resolution spectra of the region around the shadow of Mercury during its transit across the Sun can yield information about the altitude distribution of sodium in the Mercury exosphere. Measurements of sodium resonance emission have shown that both Mercury and the Moon possess sodium vapor exospheres [1,2]. In the case of the Moon, the sodium exosphere can be detected up to 1500 km above the subsolar point [3], and there is evidence for a "tail" of sodium vapor extending behind the Moon [4]. The lunar measurements give rise to a speculation that a similar extended exosphere might exist for Mercury. Efforts to detect such an exosphere using conventional ground-based spectroscopy have not been successful, perhaps because of the relatively poor spatial resolution of such measurements. Transit of Mercury across the face of the Sun gives an opportunity to look for an extended exosphere by observation of sodium vapor in absorption above the Mercury surface. Our measurements of the sodium D resonance emission from the Mercury sodium atmosphere have shown that sodium vapor is optically thick near the poles [5], so it was reasonable to expect that this sodium could be detected in absorption during transit of Mercury across the Sun.

Transits of Mercury are not common-- only fifteen transits occur in the hundred-year interval from 1951 to 2050. The transit of interest here occurred on 03:57 UT on 6 November 1993. The previous transit was on 04:07 UT 13 November 1986, and the next one will be on 21:41 UT 15 November 1999. The 1993 transit was best observed in Asia and Australia. The Hida Solar Observatory in Japan was well placed geographically for observation of the transit, and was equipped with a high-resolution solar spectrograph, capable of resolution 1,250,000 in fifth order.

Our approach was to use an imaging detector placed at the exit slit of the solar spectrograph. One dimension of the image was spatial, the other spectral. By using a slit length longer than the planetary angular width, we could obtain spectra across the planet, and into the region above and below the planet. By orienting the spectrograph slit north-south, and east-west, we could measure the spectrum across the polar and equatorial regions. We prepared two detection systems for observation of the transit. A CCD detector was provided by the Science Museum of Osaka, Japan, and an intensified video system was provided by NASA Johnson Space Center. The CCD detector provided calibrated photometric data, but with a rather slow exposure time of about 1 second, while the intensified video system was capable of collecting thirty frames per second. It was expected that selected video frames would provide very high spatial resolution. The transit time was predicted to be about 1 hour 30 minutes, so that sufficient time was available to collect images with both types of detectors.

Results. Although eastern Japan remained clear during the transit, the weather did not cooperate at the Hida Observatory site in the Japanese alps west of Osaka. Observations were possible for only a short time at the beginning of the transit. However, useful measurements were done in the short time available. The observations began with the CCD detector, and spectra across Mercury were obtained at a resolution of 840,000 for both north-south and east-west orientations of the slit. Following this, video observations were attempted, but by this time, cloud cover greatly reduced the quality of the measurement.

A sample of the CCD spectra obtained is shown in Figure 1. where the sodium D_2 solar Fraunhofer line is plotted. This particular spectrum was taken from the north polar edge of the shadow of Mercury on the Sun, and we expected to see sodium resonance absorption, Doppler-shifted by the radial velocity of Mercury at the time of the transit. The position of the absorption expected from the sodium resonance line is marked on this spectrum. There is no evidence for sodium absorption in this, or any other of the spectra that we obtained. This result means that sodium density at altitude above the surface the planet must be small, in spite of the fact that sodium vapor is found to be optically thick over the illuminated surface of the planet in the polar regions. Evidently, the sodium exosphere of Mercury is not extended in the same way as the Moon. Further analysis of the data is expected to yield upper limits to the sodium abundance at altitude above the surface.

References.[1]Potter, A.E. and T.H. Morgan (1985) Science, 229, 651 [2]Potter, A.E. and T.H. Morgan (1988) Science, 241, 2097 [3] Potter, A.E. and T.H. Morgan (1988) GRL 15, 1515 [4] Mendillo, M, J. Baumgardner,and B. Flynn (1991) GRL 18, 2097 [5]Killen, R.M., A.E. Potter, and T.H. Morgan (1990) Icarus 85, 124

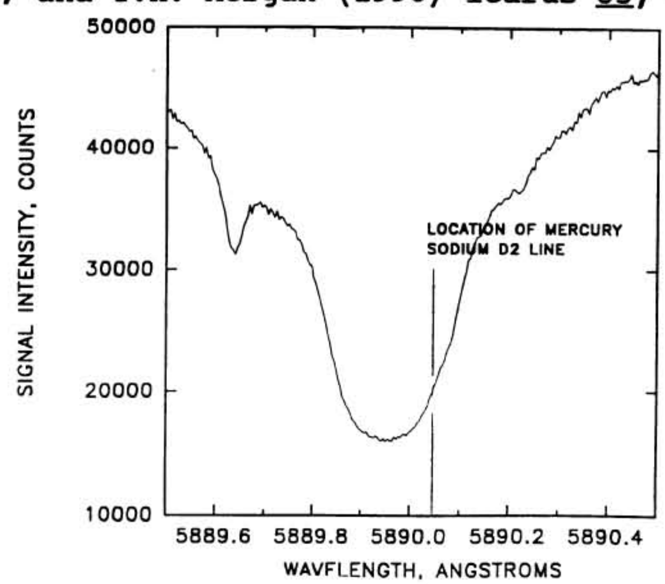

Figure 1. Solar Spectrum at the Edge of Mercury During Transit