HURA: AN INSTRUMENT FOR ATMOSPHERIC AND AEOLIAN SCIENCE. A. Soto[1], K. Nowicki[1], B. Pyke[1], M. Shoffner[1], [1]Southwest Research Institute, Boulder, CO, USA (asoto@boulder.swri.edu)

Introduction: At present, the dearth of in situ measurements within various planetary atmospheres in our solar system limits our ability to understand small-scale atmospheric dynamics, large-scale atmospheric and climatic processes, and the interaction between atmospheric and geologic processes. To address this deficiency, we have been developing Hura, a lightweight, low-power, compact, laser-based instrument capable of measuring wind velocity, atmospheric particle concentration, and atmospheric particle size and shape. Hura can be deployed on a mast or articulating arm of a planetary exploration lander and can characterize the atmospheric wind and the particles moved by that wind. Hura will be useful as part of a weather station or as a stand-alone instrument on multiple planetary surfaces, including Earth, Mars, and Titan.

We have demonstrated the instrument's capabilities and potential for future planetary exploration by operating the instrument on a rover at a Mars analog site in Iceland. We mounted Hura to the Semi-Autonomous Navigation for Detrital Environments (SAND-E) rover, which was used in a series of science and mission operation studies at a basaltic field in Lambahraun, Iceland [1]. The terrain and geologic characteristics of Lambahraun, Iceland are analogous to the basaltic detrital environments of Mars, and the cold, wet climate of Iceland is an analog for recent hypotheses concerning the early Martian climate and hydrology.

Hura was designed to perform optical anemometry, nephelometry, and tomography to characterize both the wind and atmospheric particles. Operating Hura in a Mars-like analog site allowed SwRI to demonstrate the potential and capabilities of Hura for future landed missions, particularly on Mars. As well, we demonstrated the simple operations and low-resource requirements of the instrument, which are key characteristics required for future space flight opportunities.

The Hura Instrument: Hura consists of a ring with three laser beams encoded with linear fringes and projected onto a common sampling volume at the center of the ring, as seen in Figure 1. Associated with each beam is an array of three photodiodes (PD 1, PD 2, PD 3) that are color-filtered to collect scattered light from only one laser wavelength. As a particle passes through the beam, the forward-scattered light is collected at three angles by the photodiodes.

A zoom-in of the volume of co-located observation is shown in the upper right inset of Figure 1. The blue and green fringes are oriented vertically, and the red fringes are oriented horizontally. This configuration produces a 3-D orthogonal set of fringes in the overlapping region of the beams. The bottom right panel in Figure 1 shows the time-series of the signals collected by the photodiodes for the red laser as a particle passes through the beams. Using the information in these time-series, the velocity, size, and shape of the particle is determined from the measured forward-scattered light.

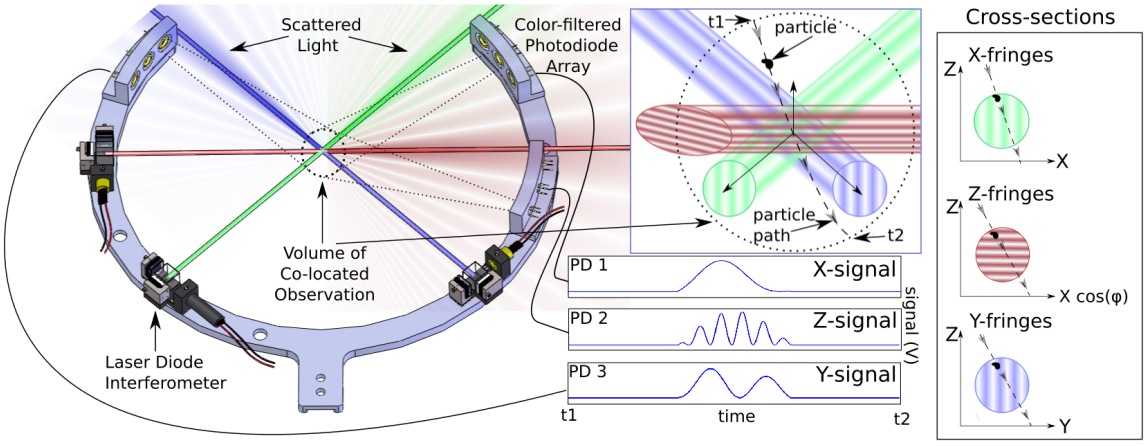

Figure 1. The Hura opto-mechanical design, based on an early version of the instrument. In the field version, the laser diode interferometers have been replaced with quasi-chirp optics, but the fundamental design works the same.

Using Hura in the Field: As part of the SAND-E field campaign, we took the two Hura instruments to the Lambahraun lava field in central Iceland. The two instruments took scientific data for 11 days from July 11, 2019 to July 21, 2019. Each instrument was operated for a number of hours each day, and the instruments were alternated as to which one was mounted on the rover and which one was mounted on a tripod. For the final accommodation of Hura on the SAND-E rover, we built a boom that was mounted on the rover and provided a clear field of view for one of the Hura instruments. The other instrument was mounted on a tripod, away from the rover operational area. By having two instruments, spatially separated in the field site, we increased the amount of data collected and increased the chances of detecting anomalous dust events, like dust devils.

Figure 2. Hura mounted on the SAND-E rover. As the SAND-E rover conducted it's semi-autonomous operations, Hura collected data on the winds and atmospheric dust.

Operating Hura is straight-forward: you turn on the instrument, start acquiring data, and then, after some time decided by the operator, you stop taking data. There are only three states for the instrument: on; on and taking data; and off. This simple level of operation facilitated incorporating the instrument onto the rover and facilitated the operation of the instrument on the tripod. For the operator in the field, the only real challenge is choosing where to place the stationary Hura. We used our assessment of the field site terrain and local weather conditions to place the stationary Hura, mounted on the tripod, in areas where it would like sample dust lifted by random dust events that occur at times in the lava fields.

Over the course of 11 days we collected almost 290 gigabytes of data from the two Hura instruments. The data was collected during quiescent conditions, windy conditions, dusty conditions, and even rainy conditions. Our preliminary analysis of the data show that there are numerous and frequent dust detections. Even when the wind dropped to near zero and the air seemed to be dust free, Hura was able to detect particles and measure the wind. At the micron and sub-micron range, there are always atmospheric particles moving through the air, which Hura can measure.

Results and Future Work: We will present the initial analysis of the data acquired in Iceland. Dust was measured for almost 2 weeks for 8 hours a day in both clear and windy conditions. Both the tripod-mounted Hura and the rover-mounted Hura measured dust lofted by wind gusts and dust devils.

The next steps include developing a science program for the use of Hura on Earth. Also, we are moving forward on developing a flight version of this instrument for use on Mars and other planetary bodies.

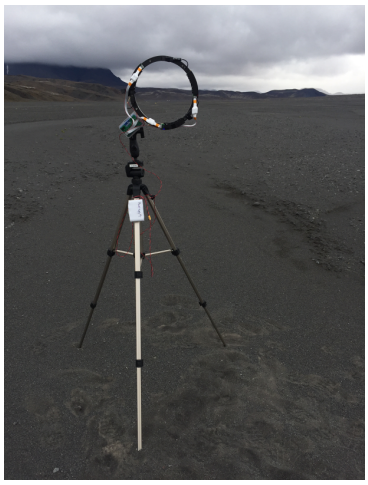

Figure 3. Hura mounted on a tripod. Typically, the Hura on the tripod was placed in an area far from the rover, in order to sample a wide variety of wind conditions.

Acknowledgments: The Southwest Research Institute has funded this initial development of the Hura instrument through internal research and development funds.

References: [1] Ewing R. C. et al. (2019) *AGU, Fall Meeting* abstract #EP24A-05