FUTURE SPACE PHYSICS AT VENUS.

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We summarize white papers recently submitted to the Planetary Science and Astrobiology Decadal Survey 2023-2032.

EXPLORING ATMOSPHERIC DYNAMICS, ESCAPE, AND EVOLUTION

Our understanding of ancient Venus and its evolution to the present day could be substantially advanced through future Space Physics investigations from orbit. We outline three high-priority strawman investigations, each possible for relative thrift with existing (or near-future) technology. 1.) To understand the physical processes that facilitate Venusian atmospheric escape to space, so that we may extrapolate backwards through time; 2.) To explore ancient Venus through the measurement of the escape rates of key species such as Deuterium, Noble elements, and Nitrogen; 3.) To understand and quantify how energy and momentum is transferred from the solar wind, through the ionosphere, and into the atmosphere, so that we may reveal its impact to the dynamics of the atmosphere.

Unravelling the drivers of Venusian ionospheric structure, energy balance and evolution, through in-situ plasma measurements at Venus

We recommend a multi-spacecraft dedicated plasma mission at Venus, capable of sampling the entire induced magnetosphere, while simultaneously measuring the upstream solar extreme ultraviolet (EUV) flux and solar wind. Such observations, obtained over a range of solar activity levels, would revolutionize our understanding of how the Venus time-dependent induced magnetosphere and ionosphere respond to solar EUV flux and solar wind variability, and would address several high priority VEXAG and planetary science goals.

The lack of a dipole magnetic field at Venus means that the solar wind interacts directly with the gravitationally bound conducting ionosphere, producing an induced magnetosphere that acts to slow down and deflect the solar wind around Venus. This interaction leads to a highly structured and dynamic plasma environment that responds strongly to changes in the solar EUV flux and the upstream solar wind conditions.

Previous in-situ observations of the Venus plasma environment have provided information on the basic physical processes that dictate this interaction, however, limitations in instrument capabilities, solar cycle phase, and orbit coverage have left a plethora of questions unanswered. In particular, comprehensive (high time cadence and full distribution) plasma, neutral, magnetic and electric and field measurements, as well as simultaneous upstream solar wind monitors, are needed to fully characterize the state of Venus' magnetosphere, ionosphere and atmosphere, and the real-time response of these to variations in upstream solar wind conditions.