Venus could be the perfect place to count meteors

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Watching meteoroids enter the Earth's atmosphere and streak across the sky as the visual spectacle known as meteors, it is one of the most awe-inspiring spectacles on Earth, often exhibiting multiple colors as they

blaze through the atmosphere, which often reveals their mineral compositions.

But what if we could detect and observe meteors streaking through the atmospheres of other planets that possess atmospheres, like Venus, and use this to better determine meteoroid compositions and sizes?

This is what a study recently accepted to *Icarus* and currently posted to the *arXiv* preprint server hopes to address as a pair of international researchers investigate how a future Venus orbiter could be used to study meteors streaking through the planet's thick atmosphere. This study holds the potential to help scientists better understand meteoroids throughout the solar system.

Here, Universe Today discusses this study with Dr. Apostolos Christou, who is an astronomer at the Armagh Observatory and Planetarium, regarding the motivation behind the study, significant results, potential follow-up studies, potentially turning this concept into reality, and potentially observing meteors on other planets throughout the solar system. Therefore, what was the motivation behind the study?

"The underlying problem we want to solve is the measurement of the flux of solid particles in space," Dr. Christou tells Universe Today. "The smallest particles (what we normally refer to as 'dust') can be efficiently counted with small-area impact detectors mounted on spacecraft, while objects larger than a meter or two (asteroids) we can find at the telescope.

"However, anything between a couple of hundred microns and a meter falls into a kind of gap; they are too rarefied to count with impact detectors and also too small to see with a telescope. The best way to look for those particles is to see them burning up as meteors in the atmosphere, essentially by treating entire planets as area detectors."

For the study, the researchers used a survey simulation toolkit known as SWARMS (Simulator for Wide Area Recording of Meteors from Space) to ascertain the feasibility if a camera onboard a future Venus orbiter could observe meteors within Venus' atmosphere. Parameters for SWARMS included using the same meteoroid populations observed on Earth for Venus, along with atmospheric modeling and the type of instrument, with the researchers putting a hypothetical meteor camera onboard the upcoming European Space Agency's EnVision orbiter.

In the end, the researchers found the number of meteors their orbiter camera could observe in the Venusian atmosphere would be 1.5 to 2.5 times greater than on Earth. The team notes this indicates the feasibility of observing meteors within the Venusian atmosphere, assuming the data would be successfully sent back to Earth. So, what were the most significant results from this study?

Dr. Christou tells Universe Today, "I'd say the two principal results are (a) that meteors at Venus occur well above the cloud layers, and (b) that they should be consistently brighter than their Earth counterparts. Point (a) removes one potential obstacle in detecting those particles in the orbital camera while point (b) tells us that any camera design flight-proven in Earth orbit should perform at least as well and probably better at Venus."

Regarding follow-up studies, Dr. Christou tells Universe Today, "There were a number of assumptions made in the study that we want to explore in later work. One of the assumptions is that the camera is at a fixed altitude above the surface. We want to better understand the implications of observing from an elliptical orbit where the altitude and therefore the range to the target changes with time and location.

"In addition, Venus's orbit is close to Earth's, and it may just be possible to detect the brightest meteors (we call these fireballs) with telescopes

from the ground as we have done with Jupiter. A future study will better quantify this possibility."

This study comes as NASA plans to launch the VERITAS (Venus Emissivity, Radio Science, InSAR, Topography, and Spectroscopy) orbiter sometime between 2029 and 2031, whose goal is to obtain high-resolution maps of Venus' surface using synthetic aperture radar and near-infrared spectroscopy to penetrate Venus' thick atmosphere.

The images obtained will provide updated data from NASA's Magellan probe in the 1990s, as this is the most recent surface data available regarding Venus' surface activity. Additionally, the European Space Agency is slated to launch EnVision in 2032 with the goal of mapping Venus' surface using synthetic aperture radar, as well.

Therefore, since this study involves putting a hypothetical meteor camera onboard the EnVision orbiter, what plans are in the works for putting such a camera on a future spacecraft?

Dr. Christou tells Universe Today, "There are no specific plans to my knowledge, however with the current level of international interest in exploring Venus, I believe this is the right time to advocate for it. Actually, there is an instrument called Mini-EUSO recording meteors from the ISS with a detection rate of ~16,000 meteors for every month of observing time.

"In comparison, a meteor survey of the kind we explore in the paper requires to detect ~200 meteors every month. This indicates that the concept is technically mature and could be implemented over the next 5–10 years say."

Venus was the sole focus of this study due to its thick atmosphere, while also having the thickest atmosphere of the terrestrial planets additionally

comprised of Mercury, Earth, and Mars. Given the results of this study, a future Venus orbiter designed to observe and detect meteors within Venus' atmosphere could be feasible while providing valuable scientific knowledge pertaining to the properties and populations of meteoroids throughout the solar system.

However, Venus is not the only planet comprised of a thick atmosphere, as the gas giants of the outer solar system (Jupiter, Saturn, Uranus, and Neptune) boast even thicker atmospheres mostly comprised of hydrogen and helium with no visible surfaces underneath. Therefore, could this meteor survey method potentially be used to identify meteors on those planets?

Dr. Christou tells Universe Today, "In some sense, we already have! In 1994, the world observed the fragments of comet Shoemaker-Levy 9 enter the atmosphere of Jupiter. More recently, amateur astronomers have observed the meteors caused by smaller, decameter-class objects against the disk of the planet.

"To observe fainter meteors, one would have to bring the detector and the planet closer together but, given that the gas giants have 1–2 orders of magnitude (with an order of magnitude being a factor of 10) more surface area than Earth, the potential is definitely there.

"Actually, such fainter meteors were detected by Voyager 1 during the brief encounter in 1979 and again more recently by the Juno orbiter. These incidents bode well for future orbital surveys."

Studying meteoroids and meteors enables scientists to better understand the composition and properties of other planetary bodies throughout the solar system, which also teaches us about the formation and evolution of the solar system, as well. As the exploration of Venus expands in the coming years, studying meteors within its thick atmosphere could

provide even more clues to how we came to be, overall.

Dr. Christou concludes by telling Universe Today, "Meteors should be ubiquitous to planets and moons with appreciable atmospheres. For instance, one should expect to see meteors on Titan and even on Triton, the largest moon of Neptune where the atmospheric pressure at the surface is 100,000x lower than Earth."

More information: Apostolos A. Christou et al, Feasibility of meteor surveying from a Venus orbiter, *arXiv* (2024). DOI: 10.48550/arxiv.2405.20063

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