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Hesperos: A Post-Alpbach Mission Result

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Abstract

Despite similarities between Venus and Earth relatively little is known about its internal structure and processes. For this reason a geophysical mission to Venus is proposed. Its aim is to investigate the existence of tectonic activity, Venus internal structure and composition. The mission consists of an orbiter and balloon that will investigate Venus for a total of five years.

1. Introduction

Despite Earth and Venus having very similar radii, mass and consequently density and gravitational acceleration, the two planets have evolved very differently. The surface pressure is 92 bar and the temperature about 464°C, which makes it a very hostile environment for human and machines alike. For this reason Venus has not received as much attention as Mars, which seems to be more benign to life. However, for a better insight into planetary formation a better understanding of why Venus has evolved so differently from Earth is essential. This is becoming more relevant with the increasing number of exoplanets being discovered.
During the Alpbach Summer School 2014 the geophysics of the terrestrial planet was the central topic. The above considerations were for a large part the reason that all groups decided to design a mission to Venus to investigate various aspects. During the post-Alpbach week in Graz two of those mission were combined and worked out in greater detail.
This paper presents the results of the post-Alpbach week. It starts with an explanation of the scientific goals of the mission. This is followed by a discussion of the required observables to fulfill the scientific goals including requirements on range, resolution, accuracy etc. Then the satellite design is discussed which will carry the payload. Subsequently, an overview is given of the mission timeline. In the last section a short summary is given and conclusions are drawn.

2. Science objectives

Surface dating of Venus has revealed that its surface is relatively young with values varying between 500 and 1000 Ma. Several theories have been developed to explain this feature. The most prominent ones are:

- the stagnant lid theory [1] and [2]
  Here, heat accumulation in the mantle results in periodic catastrophic resurfacing of large parts of the planet. Periods in between these events show hardly any activity. According this theory tectonic plates do not exist.
- tectonic plates but disimilar from Earth [3] and [4]
  Here it is assumed that tectonic plates exists but are different from Earth's. Large scale tectonic and volcanic activity should be expected.
- mantle plumes [5]
  In this theory mantle plumes cause resurfacing on a smaller scale than the stagnent lid theory.

To explain the relative young surface of Venus and to be able to determine which theory is most accurately describing Venus not only requires careful monitoring of Venus' surface, but also a deeper understanding of Venus' interior. For this reason the proposed mission is centred around two scientific questions:

1. Is Venus tectonically active and, if yes, on what time scale?
2. Is Venus' internal structure and composition similar to Earth?

To answer the first question the mission will investigate the existence of plate movement and its characteristics as well as the extent of volcanic activity. For the second question the core size and phase need to be further constrained. It will also be investigated how mantle processes drive surface activity.

Although the above objective suggest that all secrets of Venus' interior will be revealed it is not foreseen that the proposed mission will give definite answers to all these questions. However, the mission is designed in such a way that existing models of the interior of Venus can be further constrained.

3. Observables

Investigating whether Venus is tectonically active requires first of all tracking of topographical changes. However, a change in topography is not conclusive evidence of tectonic activity. It has to be related to the structure of the mantle as well. This is best studied by accurately mapping the gravity field of Venus. For further characterisation of the internal structure and processes also atmospheric species and their ratios will be determined as well as the heat signature and surface emissivity.

4. Satellite design

4.1 Orbiter

The orbiter will carry the SAR, gradiometer and IR and UV cameras. Body mounted solar panels reduce pertubations that could interfere with gradiometer measurements.

4.2 Balloon

The balloon is a so-called phase change balloon which will carry a sounding device, nephelometer, mass spectrometer and magnetometer. Its altitude will oscillate between 40 and 60 km and gradually drift to one of the poles.

5. Mission timeline

An overview of the mission timeline is given in Figure 5-1. The nominal mission duration is five years. After a Hohmann transfer period of 117 days the balloon phase will commence, which will take 25 days. During the phase the orbiter acts as a relay station to transfer science data gathered by the balloon to Earth. After the balloon phase has finished an aerobreaking maneuver will be performed to bring the orbiter in its final orbit where it will do all the measurement for the remainder of the mission.

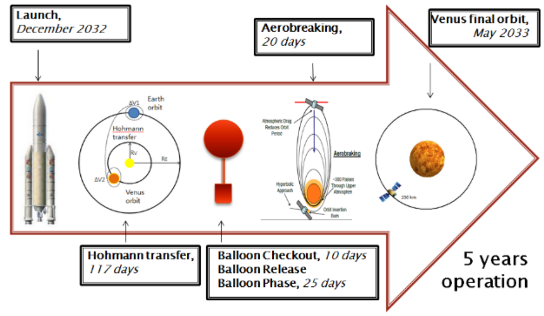

Figure 5-1: Mission timeline

6. Summary and Conclusions

The proposed mission will make a significant contribution to the understanding of planetary formation in general and how Venus has evolved in particular.

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