Mercury

Knibbe, Jurrien

2018

document version
Publisher's PDF, also known as Version of record

Summary

Observable by eye, Mercury is among the six planets along with Venus, Earth, Mars, Jupiter and Saturn that have been known in ancient cultures. Our understanding of the solar system has its foundations in the observations of these planets, and has been expanded by the detection and observations of other solar system objects and meteoritic samples. Mercury is of particular relevance because its closest proximity to the Sun makes it a unique natural laboratory for planets close to their host stars. Problematically, information on Mercury is difficult to gather. The small distance between Mercury and the Sun complicates observations of Mercury from Earth as well as the design of space missions to visit this planet. The sparse information we did gain on Mercury has signaled problems in conventional theories in various fields of science.

Two space missions have visited Mercury to this date. NASA's Mariner 10 satellite performed two fly-bys of Mercury in 1974 and one flyby of Mercury in 1975. NASA's MESSENGER satellite performed three fly-bys of the planet (two in 2008 and one in 2009) and was in a Mercury-centric orbit from march 2011 until may 2015. The data obtained by these two missions shape our present-day understanding of Mercury, complemented by Earth-based observations and more general established science.

At the time of writing, ESA and JAXA are preparing the launch of the Bepi-Colombo satellite mission to Mercury. This mission consists of two separate satellites with the largest and most advanced instrumental payload to have ever visited Mercury. The data that this mission will obtain is expected to lay the foundation for Mercury science for decades to come.

In part one of the thesis, we provide an extensive overview of the scientific progress made with respect to Mercury from the work of Johannes Kepler up to the MESSENGER mission. This is accompanied by comprehensive referencing to original works to serve the scientific community as a repository for browsing Mercury-related literature and serves advanced undergraduate and graduate students as a thorough introduction to Mercury and general planetary sciences. We begin part one with inferences from astronomy and orbital mechanics. We recount how astronomy and orbital mechanics were used to obtain physical properties of Mercury, such as its size and mass. This is followed by a description of Mercury's rotational state. After these global physical characteristics are described, we present proposed formation scenarios of the solar system, and how Mercury's formation and evolution may relate to its mass and composition. We also mention preliminary (Pre-Mariner 10) studies on Mercury's thermal evolution and interior configuration. We present the Mariner 10 observations of Mercury and later Earth-based observations in a separate chapter, to emphasize the importance of the Mariner 10 mission and how it has lead to improved understanding of Mercury in the post-Mariner 10 era.

In part two, we describe the main findings of the MESSENGER mission and

discuss how this mission has revolutionized our understanding of the planet. This discussion largely consists of research performed in light of my PhD project (performed during the years 2013-2018 at Vrije Universiteit Amsterdam), accompanied by additional notes to broaden the scope of the thesis to general science on Mercury.

We end the thesis with an outlook on science to be done on Mercury in the future (part three), which includes an interlude to the Bepi-Colombo mission. This is followed by an overall thesis synthesis chapter.