Research aimed at attaining high-pressure conditions in the interior of Jupiter (approx. 200 GPa) and deriving the equations of state for hydrogen by hydrogen shock compression experiments, using a high-powered laser (GEKKO-XII), is being conducted at the Institute of Laser Engineering, Osaka University. This work has been necessitated by inconsistencies between the theoretical model of the internal structure of Jupiter and the theoretical model of its formation, which are known to arise from uncertainties in the equations of state for hydrogen. This report describes our recently started project.

1. Introduction

Jupiter can be seen to shine particularly brightly in the night sky. Unlike stars, however, it does not generate its own light. The light from the Sun is reflected toward us from the large planetary surface, which is approximately 130 times larger than the Earth. Telescopic observation of Jupiter reveals a brown striped pattern similar to wood grain. This coloring might be due to the presence of ammonia, which is a minor component of the Jovian atmosphere. Jupiter also features a large “eye” that stares back at us. This is called the Great Red Spot, and it is so huge that it can hold four Earths simultaneously. When we see this giant eye, we feel like looking into the depths of Jupiter, to investigate whether there is anything beneath its atmosphere. However, the atmospheric thickness in that region does not permit us to do so directly.

The reason for exploring the depths of Jupiter is that important clues regarding the origins of the solar system’s largest planet are hidden here. These clues can only be found below the atmosphere, at the so-called “core,” which exists at the center of the planet (Fig. 1). Our theories regarding the origins of Jupiter can fundamentally change depending on the existence and mass of the core (Chapter 2). In general, the uncertainty regarding the mass of the core is very large, and data to support discussions regarding the origins of Jupiter is limited. This is primarily due to uncertainty regarding the high-pressure state (equations of state) of hydrogen (Chapters 3 and 4). We therefore performed high-pressure hydrogen experiments using a high-power laser, and attempted to explain the high-pressure state of hydrogen within the depths of Jupiter (Chapter 5). This paper provides an overview of theories on the formation of Jupiter, and describes the plan and current status of research to explain its internal structure by studying the hydrogen equations of state using a high-power laser.