At the Institute of Laser Engineering, Osaka University, research is underway with the aim of achieving high-pressure conditions in the interiors of Jupiter (approximately 200 GPa), and determining the hydrogen equations of state by hydrogen shock-compression experiments using a high-powered laser (GEKKO-XII). The motivation behind this work is resolving the inconsistencies between the theoretical model of the internal structure of Jupiter and the theoretical model of its formation. These inconsistencies are known to arise from uncertainties in the hydrogen equations of state.

1. Introduction

Jupiter is especially bright in the night sky, but unlike stars it does not generate its own light. Instead, light from the Sun is reflected off its large surface, which is approximately 130 times larger than the Earth. Telescopic observation of Jupiter reveals a brown striped pattern similar to wood grain. This appears to be due to ammonia, which is a minor component of its atmosphere. Jupiter also shows a feature resembling a large eye staring back at us. This is called the Great Red Spot of Jupiter, which is four times larger than Earth. This eye inspires us to peer into the depths of Jupiter to answer questions such as “Is there anything beneath this atmosphere?” However, the thick atmosphere in that region does not permit us to observe the deep interior of the planet directly.

We want to examine the deep interior of Jupiter, because this is where important clues regarding the origin of the solar system’s largest planet are hidden. These clues can be found below the atmosphere, i.e., at the core, which probably exists at the center of the planet (Fig. 1). Our fundamentals about the origin of Jupiter can change depending on the existence and mass of the core (Chapter 2). In general, uncertainty regarding the mass of the core is considerable, and discussions regarding the origin of Jupiter are not substantiated with sufficient data. This is primarily due to uncertainty regarding the high-pressure state (equations of state) of hydrogen (Chapters 3 and 4). We therefore performed experiments on high-pressure hydrogen using a high-power laser, and attempted to explain the high-pressure state of hydrogen within the deep interior 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 for explaining the internal structure of Jupiter by studying the hydrogen equations of state using a high-power laser.