Research is progressing with the goal of attaining high-pressure conditions in the interior of Jupiter (approx. 200 GPa) and settling the hydrogen equations of state by hydrogen shock compression experiments using a high-powered laser (GEKKO-XII) at the Institute of Laser Engineering, Osaka University. The background to this work is the inconsistencies between the theoretical model of the internal structure and the theoretical model of the formation of Jupiter. This is known to arise from uncertainties in the hydrogen equations of state. This report describes our project, which we recently started.

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 towards us from its large planetary surface, which is approximately 130 times larger than Earth. Observation of Jupiter by telescope reveals a brown striped pattern similar to wood grain. This appears to be due to the coloring of ammonia, which is a minor component of the atmosphere. Jupiter also features a large eye that stares back at us. This is called the Great Red Spot of Jupiter, and is so huge that it could hold four Earths together. When we see this giant eye, we want to peer back into the depths of Jupiter. Is there anything beneath this atmosphere? However, the thick atmosphere in that region will not permit us to directly peer deep into the planet.

There is a reason to want to look into the depths of Jupiter, because this is where important clues regarding the origins of the solar system's largest planet are hidden. These clues can be found at the bottom of the atmosphere. In other words, the so-called "core" which probably exists at the center of the planet (Fig. 1). Our thinking about the origins of Jupiter will be fundamentally changed depending on the existence and mass of the core (Section 2). In general, the uncertainty regarding the mass of the core is extremely large, and is currently unable to support discussions regarding the origins of Jupiter. This is primarily due to uncertainty regarding the high-pressure state (equations of state) of hydrogen (Sections 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 deep parts of Jupiter (Section 5). This paper gives an overview of theories on the formation of Jupiter, and describes the plan and current status of research to explain the internal structure of Jupiter by studying the hydrogen equations of state using a high-power laser.