CHAPTER 1

Introduction

Jupiter is the largest planet in the solar system with an equatorial diameter $\sim$ 143,000 km (May, 2015). It is composed primarily of gaseous and liquid matters mostly hydrogen ($\sim$ 89 %) and helium ($\sim$ 10 %). Jupiter has a fast rotation (10 hours), which generates the planet's strong magnetic field. The magnetic field rotates with Jupiter and sweeps up charged particles from the planet's and satellites' atmosphere. Jovian's four largest moons are Io, Europa, Ganymede and Calisto, which are called Galilean satellites shown in Fig. 1.1. Because of Jupiter large magnetosphere, Io and the other Galilean moons are always deep inside Jupiter's magnetosphere. Io is nearest to Jupiter and most affected by Jupiter's magnetosphere. Io is also the most volcanically active body in our solar system. The sulfur compounds are spewed from Io's surface forming the satellites atmosphere. Io's neutral atmosphere is ionized mainly by photoionization and charge-exchange processes. These charged particles can travel along Jupiter magnetic field lines, and finally penetrate into Jupiter's atmosphere, creating the bright aurora at the foot of magnetic flux tube.

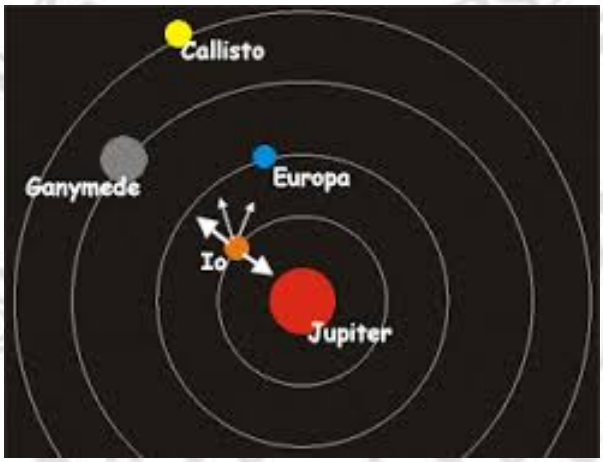

Figure 1.1: Orbit of Galilean satellites around Jupiter. White arrows represent the vectors of gravitational forces on Io from Jupiter and other satellites, causing gravitational stress and the trigger of volcanic eruption on Io (Erickson, 2015).

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่
Copyright© by Chiang Mai University
All rights reserved

1.1 Jupiter

The first spacecraft to visit Jupiter is Pioneer 10 flyby in 1973 and then Pioneer 11 in 1974. Pioneers were designed to test spacecraft system to survive the route though the asteroid belt and Jupiter's magnetosphere. The information discovered by Pioneer was used to improved the building of spacecraft to survey Jupiter in Voyager missions. Voyager 1 and 2 did flyby Jupiter in 1979. They discovered the complexity of Jovian atmosphere, containing very strong storm, lighting and, aurora. Jovian atmosphere and moons were investigated further by Galileo spacecraft, which found detail interior of this giant gas planet.

Jupiter's average distance is 4.2 astronomical units (AU) from Earth (5.2 AU from the sun). while 1 AU = 1.4960×10^{11} m. Its core probably contains rocks, metals and hydrogen components surrounded by metallic hydrogens. Outer layer includes liquid hydrogens and gaseous hydrogens (Fig. 1.2). Jupiter is windy planet. It has a very strong spinning storm like hurricane generating the Great Red Spot. The widest storm is about 3.5 times the diameter of Earth. In addition, it has dust particles from clash of comets and asteroids resulting in Jupiter's thin rings.

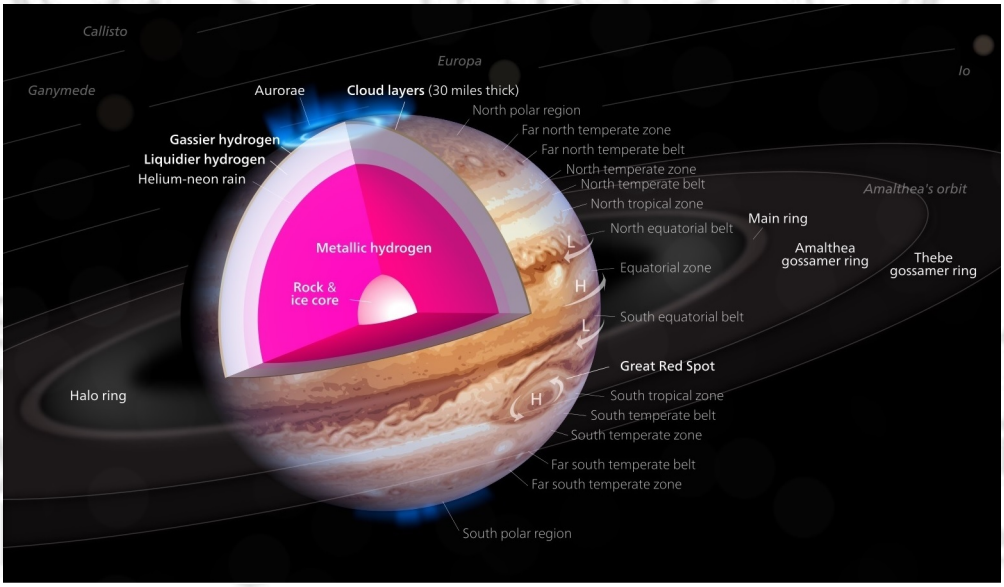

Figure 1.2: Model of Jupiter's interior (Song, 2015).

Atmospheric temperature of Jupiter vary at different layers. On the average, surface temperature is about -108°C but the interior is hot. In the core, temperature is $\sim$ 24,000°C. Below the surface, convection from the liquid layers and plasma hydrogen is probably a reason for high internal heat.

Liquid layer in the core is an electrical conductor causing Jupiter's magnetic field. The field strength is much stronger than Earth's magnetic field ($\sim$ 40 times). Jupiter's magnetosphere covers all of Galilean satellites. The magnetosphere can expand to 650 million km from Jupiter (outward distance beyond Saturn's orbit). At the equatorial region, surface magnetic field strengths is $\sim$ 4G. However Jupiter's magnetic field strengths in north pole and south pole are very different by $\sim$ 3G (14G at the north pole and 11G at the south pole), while 1 gauss = 10^{-4} tesla.

1.2 Io as the most volcanic active satellite of Jupiter

There are known 67 satellites belonging to Jupiter. The four largest moons are Galilean moons. This research focus on Io because Io has strongest interaction with Jovian magnetic field. Mean radius of Io is 1,821.6 km, while its mass is 8.93 $\times$ 10^{22} kg. Io has a core containing mostly irons (with possibility of mixing with tron sulfides). This information was recently discovered by Galileo spacecraft. Brown silicate compounds in outer layer give Io's colorful appearance. This volcanic materials, which cover all over Io, as well as Io's volcanoes were discovered mostly by Voyager spacecrafts in 1979.

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่
Copyright© by Chiang Mai University
All rights reserved

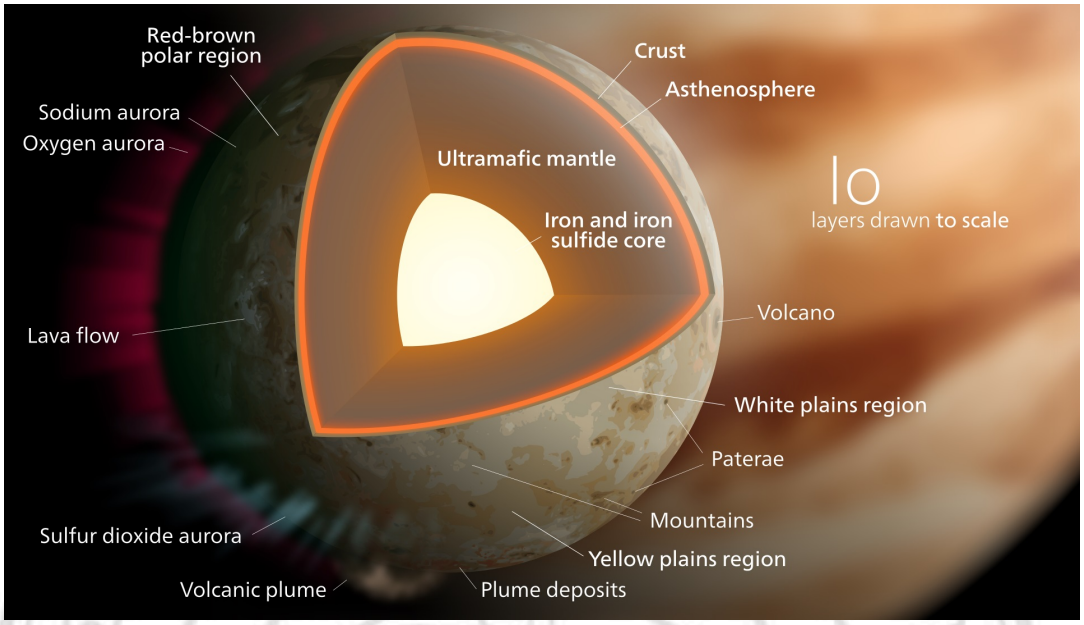

Figure 1.3: Io's interior (Song, 2015).

Io's constant volcanic activities result in Io's atmosphere composing mostly of sulfur dioxides (SO_2). While Io orbits though Jupiter's magnetic field, particles are ionized and form a doughnut-shape cloud called plasma torus. Some charge particles which travel along Jupiter's magnetic field, cause aurora in Jupiter polar region. While Io orbits deep inside Jupiter's magnetic field, some particle's interaction around the atmosphere of Io could cause the aurora on Jupiter which is called "Io's magnetic footprint".

In this research, brightness of Io's magnetic footprints are studied by IDL (Interactive Data Language). Io's footprint brightness for each observation by HST since 1997 until 2007 was recalculated base on the newly developed conversion factors (Gustin et al., 2012). Thus, the brightness variation and the extended angle of Io's magnetic footprint was analysed numerically. The interpretation of results is based on previous observations and evidences of volcanic eruptions on Io during February 2007 (Bonfond et al., 2012) and May 2007 (Yoneda et al., 2013). More detailed discussion will be in session 2.5 (also in, Fig. 2.12).

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่
Copyright© by Chiang Mai University
All rights reserved