論文内容の要旨

論文題目　EUV spectroscopic observation of Jupiter’s inner magnetosphere

（極端紫外分光による木星内部磁気圏の観測的研究）

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Almost all stars and planets emit lights in various wavelengths through resonance scattering, electron impacted excitation, charge exchange reaction, black body radiation, and so on. These emissions bring us various types of information about these space objects. For example, the temperature of the star, and the composition of a planetary atmosphere can be measured.

Among these lights, the EUV (Extreme Ultra Violet) lights (between 50 nm to 150 nm) are particularly useful for planetary science. The greatest strength of EUV is the existence of vast amounts of emission lines from atoms and ions. These lights are emitted through the resonance scattering of solar lights or collisional excitation between the ambient electrons. The brightness depends not only on the density of those atoms or ions, but also on the conditions of the excitation sources, electrons. In other words, by analyzing the EUV spectra from the targets, the condition of solar light or ambient electrons can be deduced. This method is so called, spectral diagnosis.

In the first part of this thesis, the spectral diagnosis method is used for the observation of Io plasma torus where the sulfur and oxygen ions are emitting EUV lights mainly through electron impacted excitation. Io torus is located in the inner magnetosphere of Jupiter (5.91 Jovian radii; R_J = 71500 km) where the strong planetary magnetic field is dominant. The torus emissions are able to be used as a probe of the plasma conditions of the region.

The EUV spectra acquired by NASA's Cassini spacecraft during its fly by of Jupiter on the way to Saturn are analyzed. Through the spectral diagnosis method, the electron density (N_E), core electron temperature(T_C), hot (350 eV) electron fraction (F_H), and ion compositions ratio are derived as follows: N_E ~2500 cm^{-3}, T_C ~4 eV, F_H ~3 %, $N[S^+]/N[S^{2+}]$~0.35, $N[S^{3+}]/N[S^{2+}]$~0.15, and $N[O^+]/N[S^{2+}]$~1.2. These results are consistent with that of *in-situ* measurements of Voyager-1 and Galileo spacecraft. The generation process of hot electron component is discussed. According to the relationship between the position of Io and the derived torus condition, the statistical acceleration along the field line from Io to Jupiter found to be not the main source process. The response to the variability of Jovian aurora which corresponds to the plasma condition around the middle magnetosphere (10~30 R_J) are also analyzed, and are found to have no clear relationship. These results suggest that there is another dominant source process of hot electrons or a response faster than 10 hours, which is the accumulation time of the analyzed spectra.

In order to observe Io torus in EUV range more continuously and for a longer period, the EUV spectro imager on board an Earth-orbiting satellite is designed in the second part of this thesis. Because EUV lights are absorbed in the Earth's air completely, out-of-atmosphere observations are necessary. In this thesis, the optical design is optimized for better temporal, spatial, and spectral resolutions.

The EUV lights from the target are collected by a 200 mm diameter entrance mirror, and focused onto the slit with focus length of 1600 mm. The laminar type grating diffracts the lights from the slit onto a two dimensional photon counting device. The device consists of Microchannel Plate (MCP) and Resistive Anode (RA). In addition, the shield structure prevents the detector from various types of contamination.

The CVD-SiC (Chemically vapor deposited Silicon Carbide), with its surface roughness better than 0.4 nm, is found to be the best for the surface material of mirror and grating. After the sample measurements, I have got a reflectivity curve as a function of wavelength. The reflectivity is 30-50 % for 60-150 nm which is higher than any conventional materials. For the grating, the same surface material (CVD-SiC) is adapted for the reason of its high reflectivity. After theoretical calculations and sample measurements, the best line density and depth have been determined as 1800 lines/mm and 22 nm, respectively.

The MCP as a two dimensional photon counting devise is optimized for the better quantum detection efficiency. The method of evaporating photocathode has been established through the theoretical calculation and experimental approach. I have archived the 1.5 to 50 times higher quantum detection efficiencies for EUV lights compared to a conventional one.

The RA as position sensitive encoder is optimized considering the effects of stray capacitance and the value of resistivity. Through theoretical calculation and sample measurements, I have archived 0.08 mm resolution.

The contamination evaluation is also carried on using the empirical model and Monte Carlo simulations, and the shield structure and orbital altitude were optimized. After the feasibility evaluation, I have conclude that the instrument designed in this thesis will be able to derive the plasma parameters of Io torus by 1 hour accumulation with better resolution than that of Cassini.