Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

PCG008-P08 会場:コンベンションホール 時間:5 月 26 日 14:00-16:30

インピーダンスプローブ計測における共振の Q 値の特性
What does determine the resonance Q-factors in impedance probe measurements?

鈴木 朋憲[1*], 熊本 篤志[1], 小野 高幸[1], 大家 寛[1], 上本 純平[2], 若林 誠[3], 遠藤 研[1]
Tomonori Suzuki[1*], Atsushi Kumamoto[1], Takayuki Ono[1], Hiroshi Oya[1], Jyunpei Uemoto[2], Makoto Wakabayashi[3], Ken Endo[1]

[1] 東北大学 大学院理学研究科, [2] 情報通信研究機構, [3] 新居浜工業高等専門学校
[1]Tohoku University, [2]NICT, [3]Niihama National College of Technology

The impedance probe is a powerful tool realizing highly-accurate measurements of the electron density. Detection of the upper hybrid resonance (UHR) frequency from the impedance curve provides the electron density with high accuracy. The frequency response of the antenna impedance also reflects various physical quantities and properties of a plasma in addition to the electron density. Interpretations of the antenna impedance are therefore essential for space plasma diagnostics. This paper reports on the characteristics of the ”quality factors (Q-factors)” of the UHR and sheath resonance (SHR) in impedance probe measurements.

One of the important aspects of impedance probe measurements is the ”clarity” of the resonance. The sharpness of the resonance is evaluated by the Q-factor. Sufficient insight on the Q-factor is important for evaluating the lower threshold of the electron density measurement range. Besides, the phase of the probe capacitance measured in plasma chamber indicated that characteristics of the resonance Q-factor should be examined in order to realize automatic detection of the UHR frequency. The Q-factor also has a potential to provide the electron-neutral collision frequency, which is a key parameter of the ionospheric science. However, the effect of the collision frequency on the Q-factor has not been examined. We therefore tried to evaluate the Q-factor experimentally.

We confirmed that the Q-factors of the UHR and the SHR have a clear boundary at $fpe/fce = 1$. The Q-factor indicated lower values when $fpe < fce$, while the Q-factor showed clear increases with the electron density when $fpe > fce$. This tendency was already expressed by Balmain and Oksiutik (1969). However, we also found characteristics which were not pointed out in previous works: the Q-factors were also characterized by the second harmonics of the cyclotron frequency. The effects of a hot plasma (e.g., Suzuki et al., 2009) should affects on the impedance probe measurements.

The effects of the collision frequency on the Q-factor were also examined. The impedance curves measured in the ionosphere were compared with the impedance curves measured in the plasma chamber. Contrary to expectations, the impedance curves measured in the ionosphere and in the chamber showed similar signatures in spite of the difference of 3 order magnitudes of the collision frequency. The result suggested that the mean free path is essential for evaluating the Q-factor. Careful treatments are required both for the measurements and for the numerical calculations in order to estimate the collision frequency from impedance curves.

The present study pointed out that the detailed understandings of the resonance Q-factor are necessary for further improvements of the impedance probe measurements in plasma.