Toward the automatic identification of FLR signals in the SuperDARN data by using the gradient method

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The FLR (Field Line Resonance) takes place where the frequency of an incoming wave matches the eigen-frequency of magnetospheric magnetic field lines, and excites the eigen-oscillation of the field lines. The FLR can be identified by using the unique manner of change in the amplitude and the phase of thus excited eigen-oscillation across the resonant point. That is, the amplitude is maximum at the resonant point, and the phase changes the most steeply across the resonance point. The FLR-generated eigen-oscillations can be identified in the ground magnetic field data and the ionospheric plasma velocity data. From thus identified eigen-frequency ("FLR frequency" below) one can estimate the magnetospheric plasma density along the field line which passes through the ground/ionospheric observation point.

In this study we use the SuperDARN radar data to identify FLR: For each radar beam from each SuperDARN radar, the velocity of the ionospheric plasma flow along the line of sight (VLOS) of the beam is obtained; we use the VLOS data to identify the FLR and estimate the magnetospheric plasma density. Unlike the ground magnetometer data, the SuperDARN data is two-dimensional, enabling two-dimensional estimates of the magnetospheric equatorial plasma density and magnetospheric region identification.

To achieve that, it is important to identify as many FLR events as possible. Overwrapping of non-FLR waves/perturbations hides FLR events. As a countermeasure to this problem, the so-called gradient method has been applied to the ground magnetometer data; this method cancels out the overwrapping signals by dividing the data from a magnetometer by the data from another magnetometer having an adequate latitudinal distance from the other. The division yields the amplitude ratio and the phase difference. The gradient method is effective since the FLR frequency tends to depend on the latitude more strongly than the overwrapping signals.

The gradient method is also applicable to the SuperDARN VLOS data. The field of view of each beam is divided into Range Gates (RGs below) having the same length along the beam. The identification number of the RGs increases with increasing distance from the radar. The VLOS is obtained for each RG. Thus, each RG can be regarded as a "virtual observatory."

As an initial study, we have selected an FLR event which was identified in the VLOS data of a radar (at Hankasalmi) without the use of the gradient method, selected a beam, and selected a few pairs of RGs of the beam. We then have manually applied the gradient method to the VLOS data of the above-selected RG pairs, and successfully identified the FLR. In more detail, the identification has been successful only for two paired RGs whose RG numbers differs by two. This suggest that, since the length of the RG, mapped to the meridional plane, was about 40km for this event, about 80km distance was the best (with the resolution of 40km) for this event. This distance reflects the resonance width, which is an important quantity reflecting the diffusion and dissipation of the FLR energy.

In order to identify as many FLR events as possible, it is also important to automatically identify the FLR events, since visual identification is time-consuming. The gradient method enables automatic identification more easily than analyses of VLOS itself, since the gradient method yields peaks in both the amplitude ratio and the phase difference. We have started making a program for automatic identification by applying the gradient method to VLOS; the version at the time of this abstract has successfully identified FLRs for all of the above-stated pairs of RGs.