Discovery of Double Doppler Shift Phenomena of L-band Telemetry Radio Waves Related to Thermospheric Neutral Atmosphere.

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1. Discovery of the Double Doppler Shift Phenomena.

In some of data of observations of frequency of L-band telemetry signals from Noaa satellites detected at Awara space communication center of Fukui University of Technology, the frequency shifts due to the Doppler effects are split into two frequencies. The phenomena are recognized to be newly identified in the field of studies on the Doppler effects on the telemetry radio signal and named double Doppler phenomena. The double Doppler phenomena, then consist of two kinds of Doppler shift frequencies; one is the component called main Doppler shift (MDPS) which coincides with the predicted Doppler shift frequency and the other is subsidiary Doppler shift frequency (SDPS) which deviates from MDPS with deviation frequency gap depending on the observation directions of satellites.

2. Modes of Double Doppler Phenomena.

The modes of deviations of SDPS from MDPS are divided into two main categories with different details. We then define the types of the mode of appearance of SDPS with respect to MDPS. The types belong to category of full coverage of the observation period are defined type A while the types which are observed partially during the observation period over the telemetry station are defined as B type. The type A phenomena are further divided into Ad, Au and Am. The double Doppler phenomena Ad is the type of phenomena where SDPS frequency is in lower side of the MDPS frequency. The phenomena of type Au is characterized by SDPS frequency that is above the frequency of MDPS while the phenomena of type Am is characterized by crossing of SDPS and MDPS frequency during satellite observations.

3. Maser Phenomena under the Zeeman Effects.

The occurrence probability of the double Doppler phenomena is about 10% and many of the phenomena are detected in the entire intervals as the cases of the category A phenomena. The mechanism is then not related to the instrumentation nor related to the reflection obstacle on the ground. The ionospheric plasma effect on the double Doppler phenomena is can not be consider because of the frequency range of Noaa satellite such as 1698MHz and 1707MHz. Then we propose the mechanism of the maser phenomena associated with Zeeman effect here. In the case of the Noaa 12 and 18 satellites whose telemetry wave frequency is 1698MHz, the resonance line frequency 1699.1882MHz of NO neutral particles is able to match to the maser effect in the region between 130km to 280km in the lower to middle thermosphere when there exists Zeeman effects due to the geomagnetic fields whose intensity varies with height. The same mechanism can be considered for the cases of Noaa 14 and 17 satellites whose telemetry radio wave frequency is 1707MHz. In these cases, the resonance line frequency 1709.2877MHz of N_2O neutral particles becomes origin of maser phenomena also associated with Zeeman effects.

4. Wind Shear Effects.

It is, however, essential to consider the two different winds at different height in the NO atmosphere by which the satellite radio wave frequency experiences different Doppler shift to interpret the observed frequency gap between MDPS and SDPS frequencies; the maximum gap frequencies are in the range from 20kHz to 60kHz depending on the observation cases. To meet with observed frequency gap between MDPS and SDPS frequencies, the wind shears are estimated to be dominated in the north-south, or vice versa, directions also being dominated in the horizontal direction. From the observed data the estimated shear velocities are in a arrange from 250m/sec to 2km/sec. It is suggested that the wind shear in the region in upper E and lower F regions of thermosphere is well correlated to the wind shear of the low thermosphere which is related to the formation of the sporadic E layer.