國立中央大學太空科學與工程學系

Department of Space Science and Engineering, National Central University

專題演講

Turbulence Spectra of Electron Density and Magnetic Field Fluctuations in-situ measured by Voyager 1 in the Local Interstellar Medium

Speaker： 李昆翰 博士

(中央研究院地球科學研究所)

Time： 109 年 9 月 25 日 星期五 14:00-15:00

Place： 健雄館(科四館) S4-811 教室

摘 要/Abstract：

In 1976, Lee and Jokipii first suggested that the interstellar turbulence at the length scale between 10^8m and 10^{18}m (100 light-years) has a Kolmogorov-like spectrum ($P \propto k^{-5/3}$) based on observations of radio wave scintillations and interstellar clouds. Many later ground observations confirmed this speculation and constructed the composite spectrum extending from $10^{6.4}$m to 10^{18}m. The length scale of the spectrum obtained in these studies is in the inertial range ($10^6 - 10^{18}$m).

The present study presents the turbulence spectra of both magnetic and electron density fluctuations in-situ measured by Voyager 1 in the local interstellar medium from 2012 to 2019. The main results are listed below:

(1) Both the electron density and magnetic fluctuation spectra in-situ measured by Voyager 1 show Kolmogorov power law ($P \propto k^{-5/3}$) in the inertial range.

(2) The electron density turbulence measured by Voyager 1 in the local interstellar medium shows higher intensity than that of the remote observations in the distant interstellar medium by a factor of $10^{1.96} \approx 91$. The turbulence spectrum in the local interstellar medium is a superposition of a higher amplitude spectrum of heliospheric origin and a lower amplitude spectrum of distant interstellar medium.

(3) The electron density and magnetic fluctuation spectra are simultaneously observed for six individual time periods. The ratios of $\delta B_\perp$, $\delta B_\parallel$ and δn can be used to identify the presence of the Alfvèn, fast, slow, entropy and arc/spherically polarized Alfvèn waves. The power of perpendicular magnetic fluctuations is usually higher than that of parallel magnetic fluctuations, indicating the dominance of Alfvén waves in turbulence spectrum.

(4) The relation between the outer scale L_0 and the root-mean-square values of magnetic and electron density fluctuations are obtained. In the calculation with only in-situ measured data of electron density and magnetic field, we obtain $\langle \delta B^2 \rangle^{1/2} \approx \langle B \rangle \approx 0.45\text{nT}$ and $\langle \delta n^2 \rangle^{1/2} \approx \langle n \rangle \approx 0.096\text{cm}^{-3}$ for $L_0 = 3\times 10^{14}$m. This outer scale can be interpreted as the spatial range of the disturbed local interstellar medium. For the typical interstellar cloud size $L_0 = 10^{18}$m, we obtain $\langle \delta B^2 \rangle^{1/2} = 6.97\text{nT}$ and $\langle \delta n^2 \rangle^{1/2} = 0.43\text{cm}^{-3}$. The high magnetic strength of tens of nanotesla has been observed at the Galactic scale.

(5) The results from both remote and in-situ measurements can provide a verification of theoretical models in the inertial and kinetic ranges.

※歡迎聽講※ ~請聽講者提早入座~