# A Case Study of High speed Flow of High Density

W.S. Shang[1], Q.Q. Shi[1], A.M. Tian[1], M.W. Dunlop[2], Z.H. Yao[3]

[1]Shandong Provincial Key Laboratory of Optical Astronomy and Solar-Terrestrial Environment, School of Space Science and Physics, Shandong University at Weihai, Weihai, 264209, China;

[2]Space Sciences Division, SSTD, Rutherford Appleton Laboratory, UK;

[3]Institute of Geology and Geophysics Chinese Academy of Sciences, Beijing 100029, China.

Email:sqq@sdu.edu.cn

Abstract

Combining with ARTEMIS (P1 and P2) and Wind data, we have investigated the magnetic field and plasma properties in the distant magnetotail during the period January to December 2012. Of particular interest is their characteristic of density near the neutral sheet. We present the discovery of high speed flow of high density in the distant tail under the northward interplanetary magnetic field (IMF) conditions. Multi-satellite observations can present the tailward high speed flow accompany with high density plasma when the satellites were crossing the neutral sheet in the north of the ecliptic plane under the active interplanetary condition. And in this case, single satellite observation shows that the earthward high speed flow accompany with high density plasma because of the influence of solar wind dynamic pressure. And the other satellite observed the tailward high speed flow due to solar wind entry into the magnetotail.

## 1. Introduction

The motion processes of high speed flows play a major role in magnetic flux transport, magnetic field perturbation, triggering of substorm and the current system formation in the magnetotail [1]. Many studies using quite different methods have shown that high speed flows are associated with relatively low plasma density in all plasma sheet regions and are positively correlated with geomagnetic activity [2,3]. There are many studies about the high speed flow in the inner plasma sheet [1,3,4]. However, the nature of high-speed flows is still dimness. And there is no study on high speed flow of high density in the distant magnetotail. In this study, we show observations of high-speed flows of high density in the distant magnetotail near the moon which are greater than 1 cubic centimeter, when the satellites were crossing the neutral sheet.

## 2. Observations

We use ARTEMIS and Wind satellites to detected the magnetic field and plasma data of the magnetosphere and interplanetary, respectively. In this event, the ARTEMIS satellites were simultaneously observing the high speed flow of high density (Figure 1). And the neutral sheet is on the north of the ecliptic plane in the summer period. Figure 2 shows an overview of the data. The upstream solar wind magnetic field and plasma data, measured by Wind, is shown in Figures 2a–2e. Based on the velocity of solar wind, the Wind data has been shifted by 3638 second so that it corresponds to the conditions in the distant magnetotail. What's more, the condition of solar wind was instable.

At 15:00UT, P1 was located in the boundary of magnetosphere ($V_X \approx 0, B_X \approx 18$ nT), and subsequently encountered the earthward high speed flow of low density. Then the satellite was detected the tailward high speed flow of high density accompanied by $B_X$ and magnetic field strength decrease. Furthermore, the value of $B_X$ was from negative to positive, confirming that the satellite was crossing

978-1-4673-5225-3/14/$31.00 ©2014 IEEE

the neutral sheet during this period. If they were due to solar wind entry magnetotail, then this would be a tailward high speed flow with the same density of interplanetary which is observed by P1 during the interval 15:35 15:50. And the ion energy was smaller than other high speed flows (Figure 2j). It is expected that the tailward high speed flow of high density is exist in the distant magnetotail. However, the P2 detected the earthward high speed flow of high density (Figure 3). And the $B_Z$ was found from positive to negative, and then return to positive. At the same time, the ion velocity was detected from negative to positive. The density of the solar wind is about 5 $cm^{-3}$, which is larger than the ion density detected by P2 satellite. We can get that because of the change of dynamic pressure or other influence factor, the high speed flow of high density may be derived from the lobe magnetic reconnection under the northward interplanetary magnetic field condition.

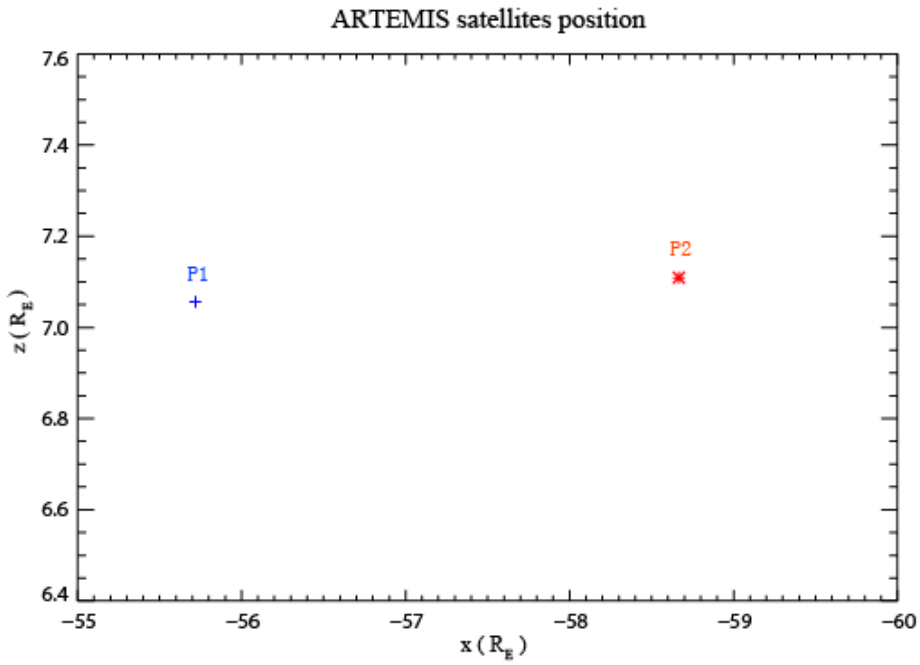


Figure 1. ARTEMIS satellite position plot in the x-z GSM plane.

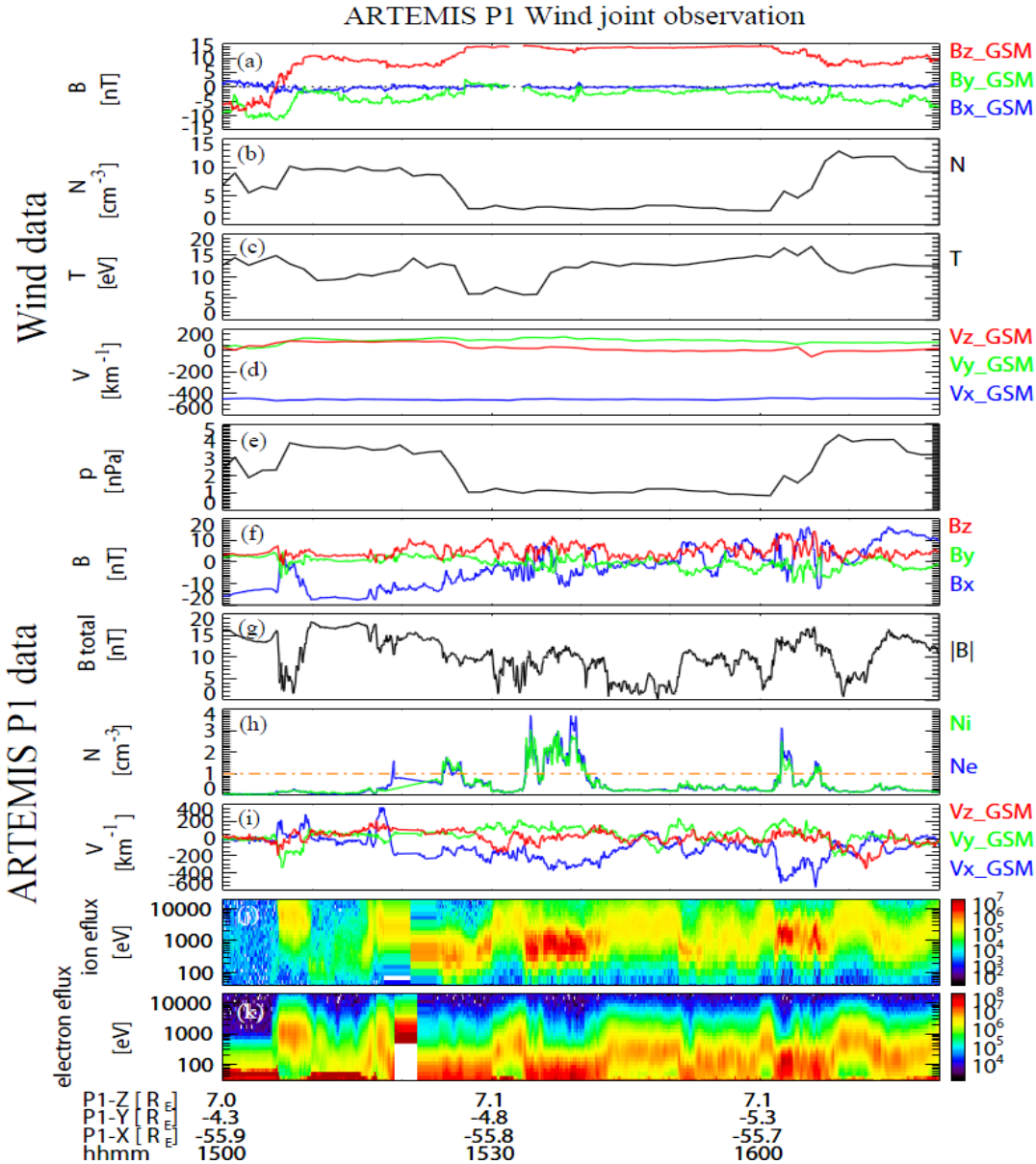


Figure 2. (a–e) Wind measurements of the magnetic field components, ion density, ion temperature and dynamic pressure of the IMF in the GSM coordinate system, shifted by 3638 second. (f–k) ARTEMIS P1 magnetic field components, magnetic field strength, ion and electron density, ion velocity, and ion and electron energy flux spectrogram. Vectors are presented using the GSM coordinate system.

## 3. Conclusion

Using the observation of ARTEMIS and Wind satellites, we have studied the high speed flow of high density in the magnetotail. The multi-satellite observations show the tailward high speed flow accompany with high density plasma when the satellites were crossing the neutral sheet in the north of the ecliptic plane under the active interplanetary condition. Furthermore, the single satellite show the earthward high speed flow with high density plasma because of the influence of solar wind dynamic pressure. And the other satellite found that the tailward high speed flow of high density due to solar wind entry into the magnetotail.

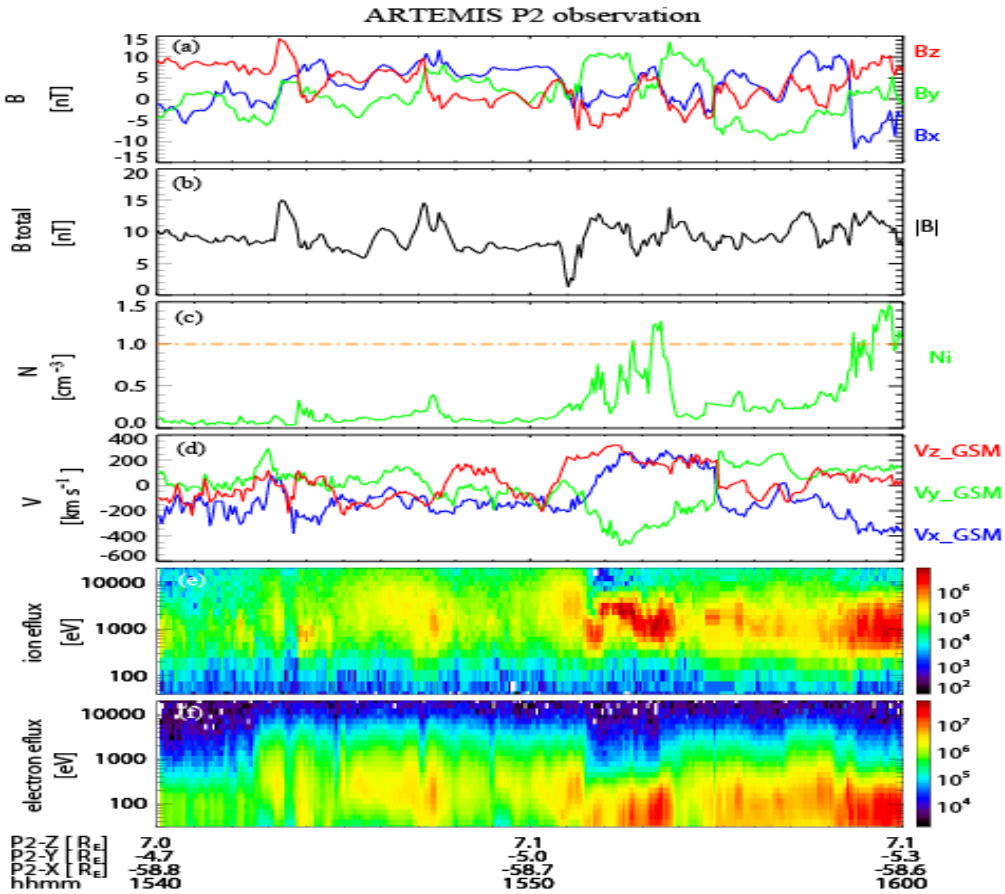


Figure 3. ARTEMIS P2 magnetic field components and magnetic field strength, ion density, ion velocity, ion and electron energy flux spectrogram.

## 4. Acknowledgments

We thank CW Carlson and JP McFadden for the use of the ESA data; KH Glassmeier, U Auster, and W Baumjohann for the use of FGM data. The work is supported by NNSFC 41031065, 41074106, 41322031, the Shandong Natural Science Foundation (Grant No. JQ201112).

## 5. References

1. W. S., Shang et al., "Braking of high-speed flows in the magnetotail: THEMIS joint observations", Chin. Sci. Bull, 2014, 59, 326–334
2. V., Angelopoulos et al., "Statistical characteristics of bursty bulk flow events", J. Geophys. Res., 1994, 257.
3. J. B., Cao et al., "Joint observations by Cluster satellites of bursty bulk flows in the magnetotail", J. Geophys. Res., 2006, 111, A04206, doi:10.1029/2005JA01 1322.
4. Y. D., Ma et al., "Statistical analysis of earthward flow bursts in the inner plasma sheet during substorms", J. Geophys. Res., 114, 2009, A07215, doi:10.1029/ 2009JA014275.