# Analysis of WIND Spacecraft Data: Data Set Description

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## Overview

This data set is comprised of one years worth of solar wind measurements. The purpose of this project is to find the fundamental parameters that determine the onset of energy dissipation in the solar wind. The description of the sample file will be laid out in the following sections.

- Data Set Structure
- Expected Model/Functional Form
- Formulas

This project may add some complication in the fact that the independent variables supplied by the spacecraft may not be the best form when fitting the data. Modifications to the independent variable to derived variables may be important. Note: all formulas and equations connecting independent and derived variables will be included in this document.

**All variables are pre-screened to be within valid min and max values!**

## Data Set Structure

The data set, *Terres_Li_Sample_Data_Set.csv*, is broken into three distinct sections. The independent variables, the derived variables, and the dependent variables.

### Independent Variables

The independent variables are broken into two distinct sets. The given spacecraft data, and the derived spacecraft data. In the data set columns 0 and 1 are simply the timestamps for each event. Since each period is independent of time there is not connection between each time period.

Columns 3 through 21 represent the independent variables that will be needed for the functional fit.

- Column 3: Bx - The x-component of the solar wind magnetic field. Units recorded in Tesla.
- Column 4: By - The y-component of the solar wind magnetic field. Units recorded in Tesla.
- Column 5: Bz - The z-component of the solar wind magnetic field. Units recorded in Tesla.
- **Column 6:** Bmag_avg - The magnitude of the magnetic field. Units recorded in Tesla. **This is one parameter of the most importance. The value is constructed through** $|B| = \sqrt{Bx^2 + By^2 + Bz^2}$
- **Column 7:** Ni_avg - The number density for ions. units recorded in $m^{-3}$.
- Column 8: Vx - The x-component of the solar wind velocity. Units recorded in m/s.

- Column 9: Vy - The y-component of the solar wind velocity. Units recorded in m/s.
- Column 10: Vz - The z-component of the solar wind velocity. Units recorded in m/s.
- **Column 11:** VSW - This is the magnitude of the ion velocity of the solar wind. Value is important in the calculation of various break features. More detail will be provided in the formulas.
- Column 12: Vth_mag_ion - The magnitude of the thermal ion velocity. Used to derive the ion temperature in column 19.
- Column 13: Vth_para_ion - The parallel thermal velocity. Used to derive the ion temperature in column 20. Units m/s
- Column 14: Vth_perp_ion - The perpendicular thermal velocity. Used to derive the ion temperature in column 21. Units m/s
- Column 15: Ne - The electron number density. units recorded in $m^{-3}$.
- Column 16: Ue - The electron bulk speed. units m/s.
- Column 17: Te - The electron temperature. units Kelvin.
- Column 18: BUFFER
- **Column 19: Ti - Derived** Ion temperature. Units Kelvin. This calculation is conducted in the preparation of this data set. This value is a key parameter.
- **Column 20: Ti_para - Derived** Parallel Ion temperature. Units Kelvin. This calculation is conducted in the preparation of this data set. This value is a key parameter.
- **Column 21: Ti_perp - Derived** Perpendicular Ion temperature. Units Kelvin. This calculation is conducted in the preparation of this data set. This value is a key parameter.

The parameters that are bolded are considered the key fitting parameters!

# Derived Data:

In this section we display the formula calculations for the derived data. These parameters are in columns . Each equation will be the proper form and then defined in terms of each of the parameters. NOTE: Constants $n_i, m_p, \mu_0, \epsilon_0, c, andk_b$ are all given in column 51!

Column 23: VA

$$V_A = \frac{B^2}{\sqrt{\mu_0 n_i m_p}} = \frac{\text{Bmag\_avg}^2}{\sqrt{\mu_0 m_p N i_{avg}}} \tag{1}$$

Column 24: Beta

$$\beta = \frac{v_{th}^2}{V_A^2} = \frac{\text{Vth\_mag\_ion}^2}{VA^2} \tag{2}$$

Column 25: Beta_para

$$\beta_{\|} = \frac{v_{th,\|}^2}{V_A^2} = \frac{\text{Vth\_para\_ion}^2}{VA^2} \tag{3}$$

Column 26: Beta_perp

$$\beta_\perp = \frac{v_{th,\perp}^2}{V_A^2} = \frac{\text{Vth\_perp\_ion}^2}{VA^2} \tag{4}$$

Column 27: Omega_i

$$\Omega_i = \frac{eB}{m_p} = \frac{e(\text{Bmag\_avg})}{m_p} \tag{5}$$

Column 28: omega_pi

$$\omega_{pi} = \sqrt{\frac{n_i e}{\epsilon_0 m_p}} = \sqrt{\frac{\text{Ni\_avg} \cdot e}{\epsilon_0 m_p}} \tag{6}$$

Column 29: omega_pe

$$\omega_{pe} = \sqrt{\frac{n_e e}{\epsilon_0 m_p}} = \sqrt{\frac{\text{Ne} \cdot e}{\epsilon_0 m_p}} \tag{7}$$

Column 30: rho_i

$$\rho_i = \frac{v_{th,\perp}}{\Omega_i} = \frac{\text{Vth\_perp\_ion}}{\text{Omega\_i}} \tag{8}$$

Column 31: rho_s

$$\rho_s = \rho_i \sqrt{\frac{ZT_e}{2T_i}} = \text{rho\_i}\sqrt{\frac{Te}{2 \cdot Ti}} \tag{9}$$

Column 32: rho_c

$$\rho_c = d_i + \sigma_i = \text{d\_i} + \text{sigma\_i} \tag{10}$$

Column 33: d_i

$$d_i = \frac{\rho_i}{\sqrt{\beta}} = \frac{\text{rho\_i}}{\sqrt{\text{Beta}}} \tag{11}$$

Column 34: d_e

$$d_e = \frac{c}{\omega_{pe}} = \frac{c}{\text{omega\_pe}} \tag{12}$$

Column 35: sigma_i

$$\sigma_i = \frac{v_{th,||}}{\Omega_i} = \frac{\text{Vth\_para\_ion}}{\text{Omega\_i}} \tag{13}$$

Column 36: Lperp

$$L_{perp} = \frac{V_{sw}}{2\pi \times 10^{-4}} = \frac{VSW}{2\pi \times 10^{-4}} \tag{14}$$

**Column 37: lambda_r**

$$\lambda_r = C_0 L_\perp^{1/9} (d_e \rho_s)^{4/5} = Lperp^{1/9}(\text{d\_e} \cdot \text{rho\_s})^{4/5} \tag{15}$$

# Dependent Variable

The variable that we are fitting is $k_brk$. This value is given in column 47. We relate $k_brk$ to $\lambda_r$ by the following.

$$k_{brk}^{-1} = \lambda_{brk} \propto \lambda_r \tag{16}$$

The proportionality is related to the model in the following section. The values of $\lambda_{brk}$ are given in column 48 as l_brk.

# Expected Model/Functional Form

From some of our previous work we found that energy is likely dissipated at the disruption scale in the solar wind. The scale is given by the following expression.

$$\lambda_r = C_0 L_\perp^{1/9} (d_e \rho_s)^{4/5} \tag{17}$$

Each parameters formula is described in the formula section above! The relationship to the independent variables are also discussed! Thus, we define a dimensional model as follows.

$$\boxed{\lambda_{r,model} = C\rho_s \left(\frac{L_\perp}{\rho_s}\right)^\alpha \left(\frac{d_e}{\rho_s}\right)^\beta} \tag{18}$$