peacemoments - B-field Aligned Moments

velocity and heat flux vector

Given the GSE velocity **v** and the magnetic field **B**, the projections of **v** parallel and perpendicular to **B** are given as:

$$\mathbf{v}_{para} = (\mathbf{v}.\mathbf{b})\ \mathbf{b}$$
$$\mathbf{v}_{perp} = \mathbf{v} - (\mathbf{v}.\mathbf{b})\ \mathbf{b}$$

where **b** is the magnetic field normalized to 1, i.e. $\mathbf{b} = \mathbf{B} / |\mathbf{B}|$. These vectors are given in the output of the *peacemoments* software when the “B-field Aligned” output option is chosen.

Note that also:

$$\mathbf{v} = \mathbf{v}_{para} + \mathbf{v}_{perp}$$

and the magnitude of the GSE velocity is given by:

$$|\mathbf{v}| = \mathrm{Sqrt}[\mathbf{v}_{para}{}^{2} + \mathbf{v}_{perp}{}^{2}]$$

Note that $\mathbf{v}_{para}$ is not the same as **v** rotated to a coordinate system in which the z-axis is parallel to the magnetic field, which is given by:

$$\mathbf{v}_{BFA} = R\mathbf{v}$$

where the rotation matrix R is given by:

$$R = \begin{bmatrix} C & -b_x b_y/C & -b_x b_z/C \\ 0 & b_y/C & b_z/C \\ b_x & b_y & b_z \end{bmatrix} \qquad (1)$$

where $C = \mathrm{Sqrt}[b_y^2 + b_z^2]$. Here **b** is the normalized B-field vector.

The relations between $\mathbf{v}_{BFA}$, $\mathbf{v}_{para}$ and $\mathbf{v}_{perp}$ are:

$$\mathbf{v}_{para}{}^2 = v_{BFA,\,z}{}^2$$
$$\mathbf{v}_{perp}{}^2 = v_{BFA,x}{}^2 + v_{BFA,y}{}^2$$

<u>pressure tensor and temperature</u>

Firstly, the pressure tensor is rotated so that the z-axis is parallel to the magnetic field:

$$P_{BFA} = R^T P R$$

where the rotation matrix R is given in Eq. (1). Then

$$P_{para} = P_{BFA,\,zz}$$
$$P_{perp,\,1} = P_{BFA,\,xx}$$
$$P_{perp,\,2} = P_{BFA,\,yy}$$
$$P_{perp} = (P_{BFA,\,xx} + P_{BFA,\,yy})/2$$

The temperature is then given by

$$T_{para} = P_{para} \,/\, Nk$$
$$T_{perp,\,1} = P_{perp,\,1} \,/\, Nk$$
$$T_{perp,\,2} = P_{perp,\,2} \,/\, Nk$$
$$T_{perp} = P_{perp} \,/\, Nk$$

where N is the number density and k is Boltzmann's constant ($1.3807\text{x}10^{-23}$).

The relationship between T, T_{para} and T_{perp} is:

$$T = (2T_{perp} + T_{para}) \,/\, 3$$