

CLUSTER and MMS missions : Estimation of the gradient of a field with a flattening tetrahedron

*Gerard Marcel CHANTEUR^{1,2,3}

1. CNRS, 2. Ecole Polytechnique, 3. UPMC

The ESA mission CLUSTER, successfully launched in 2000 has been the first one to involve four identical spacecraft orbiting simultaneously around the Earth in order to provide a three dimensional view of plasma processes with inter-spacecraft distances varying from a few tens to a few thousands of kilometers. CLUSTER is going on and has already demonstrated the impressive benefit of simultaneous multipoint observations; its success has triggered new projects like the NASA MMS mission, launched in 2014, which is currently investigating shorter scales than CLUSTER. For not too large inter-spacecraft distances, multi-spacecraft data analysis methods have been developed to estimate gradients of fields : see the detailed presentations in two ISSI books [1,2]. It has been demonstrated by Chanteur [3] that estimated gradients are spoiled by large errors when the tetrahedron of spacecraft flattens, which occurs twice per orbit and sometimes during “interesting” time intervals. Shen et al. [4] proposed to estimate gradients under such difficult configurations by making use of the principal axes of the inertia tensor of the configuration of the cluster : that solves the problem only partially, but the divergence remains along the normal to the plane of the singular “flat” tetrahedron. We have designed a rigorous analysis of the flattening tetrahedron by making use of a frame of reference attached to the tetrahedron which allows to estimate all components of the gradient, avoiding any divergence but nonetheless the estimated gradient is affected by the geometrical amplification of errors due to the flattening.

References

1. ISSI book, (1998) Analysis Methods for Multi-Spacecraft Data, edited by Paschmann, G., and Daly, P. W., ISSI Scientific Report SR-001, International Space Science Institute, Bern, Switzerland, 1998.
2. ISSI book, (2008) Multi-Spacecraft Analysis Methods Revisited, edited by Paschmann, G., and Daly, P. W., ISSI Scientific Report SR-008, International Space Science Institute, Bern, Switzerland, 2008.
3. Chanteur, G., (1998) Spatial interpolation for four spacecraft: Theory, in: Analysis Methods for Multi-Spacecraft Data, edited by Paschmann, G. and Daly, P. W., ISSI Scientific Report SR-001, pp. 349-369, International Space Science Institute, Bern, Switzerland, 1998.
4. Shen, C., et al. (2012), Spatial gradients from irregular, multiple-point spacecraft configurations, J. Geophys. Res., 117, A11207, doi:10.1029/2012JA018075.

Keywords: magnetospheric physics, multi-spacecraft data analysis, reciprocal vectors of a tetrahedron