# Reply

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The comment of *Daglis and Sarris* [this issue] raises two separate issues: (1) whether the energy density of $O^+$ ions in the energy range from 0.1 to 16 keV is a substantial part of the entire energy density of these ions, and (2) whether the conclusions of *Lennartsson* [1995] apply to $O^+$ ions with energies much greater than 16 keV. Before these issues are addressed, it must be emphasized that the study in question deals with the statistical correlation of magnetospheric $O^+$ ions with conditions in the solar wind, not with geomagnetic conditions per se. It is worth keeping in mind that our present view of magnetospheric dynamics has been shaped in large part by magnetic field observations from Earth, most of which have been made at geomagnetic latitudes of less than 70°.

Previous studies of magnetospheric ion composition have demonstrated that $O^+$ ions with energies below 20 keV typically increase in abundance with increasing geomagnetic activity, both in the inner magnetosphere [e.g. *Balsiger et al.*, 1980; *Lennartsson and Sharp*, 1982; *Young et al.*, 1982] and in the magnetotail [e.g. *Lundin et al.*, 1982; *Lennartsson and Shelley*, 1986], and are in that sense no different from the more energetic $O^+$ ions. In fact, the number density of 0.1- to 16-keV $O^+$ ions in the plasma sheet, as illustrated in Figure 6 of *Lennartsson and Shelley* [1986], shows a dependence on the AE index which is similar to that demonstrated by the $O^+$ energy density in Figure 2 of *Daglis and Sarris* [this issue], including the roughly 10-fold increase, "on average", between AE = 100 nT and AE = 1000 nT and the broad scatter of points about this general trend. The intent of *Lennartsson* [1995] is to inquire into the possible causes, not only of this well-known trend but also of the scatter.

As far as issue 1 is concerned, it is important to distinguish between the plasma sheet and the ring current. The study is for the most part about $O^+$ ions in the plasma sheet ($10\ R_E < R < 23\ R_E$), where the ion population as a whole, originally equated with "protons", is known to have a mean energy typically well below 20 keV. It seems quite reasonable that the 0.1- to 16-keV range encompasses a substantial part of the $O^+$ energy density in that region of space. The same is not true in the ring current, in general, although conditions vary a great deal in both space and time. In any case, the $O^+$ data from $R < 10\ R_E$ are only discussed in terms of number density [see *Lennartsson*, 1995, Figure 8].

To pass a fair judgment on issue 2, it is essential to separate conclusions from ruminations. This study does not claim to have resolved the different effects of kinetic *K* versus electromagnetic *P* solar wind energy fluxes on the $O^+$; it demonstrates that the measured $O^+$ energy density in the plasma sheet is statistically well correlated with either *K* or *P*, when those fluxes have both been averaged over a few preceding hours, but it notes that, on average, the $O^+$ energy density is more nearly proportional to *K* (see the first three paragraphs of the discussion section on page 23,631). The primary objective, as stated, is to address the following question: is it necessary for the IMF to be southward, that is for $B_z$ to be negative, in order to have solar wind energy, be it of kinetic or electromagnetic origin, transferred across the magnetopause? The conclusions are that (1) the associated extraction and energization of terrestrial ions, as manifested by both the outward flux, where measured, and the near-equatorial concentration of 0.1- to 16-keV $O^+$ ions, do not have a strong dependence on the polarity of the IMF $B_z$ and therefore (2) the magnetopause must be largely "open" also during times of northward IMF.

To suggest that conclusions 1 and 2 also apply to much more energetic $O^+$ ions in the inner magnetosphere may seem a daring proposition, and *Daglis and Sarris* [this issue] are justifiably skeptical on that point. However, the familiar fact that magnetic storm injections of high-energy ions into the ring current are usually preceded by a finite period of southward IMF does not, in itself, imply that the magnetopause is "less open" during times of northward IMF. Even the 0.1- to 16-keV $O^+$ ions inside the ring current, measured in terms of their number density [e.g. *Lennartsson and Sharp*, 1982], are strongly and positively correlated with the magnitude of the negative $D_{ST}$ index, and yet, that same number density shows virtually no dependence on the IMF $B_z$ polarity alone, when samplings are restricted to longer (of order 10 hours) periods of constantly southward or northward IMF [*Lennartsson*, 1995; Figure 8]. Presumably, the onset of storms (and substorms) entails more than enhanced solar wind energy flow across the magnetopause.

The ring current is, indeed, a large energy sink, but its aggregate kinetic energy, even at the peak of a large storm, is only a part of the energy content of the entire magnetosphere. Thus, having the AMPTE/CCE charge-energy-mass (CHEM) data and being able to measure essentially the entire ion energy distribution in the inner magnetosphere ($R < 10\ R_E$) is invaluable, but to be able to place such data in the magnetospheric energy budget, one also needs to know the kinetic and electromagnetic energy content of the vast magnetotail, including the plasma sheet. It may well be, as perhaps suggested by the ISEE 1 ion composition data [*Lennartsson*, 1992], that the spatially integrated kinetic energy in the plasma sheet, including that of the solar origin ions, peaks during extended periods of northward IMF, so the mechanism of magnetic storms (and substorms) may have as much to do with internal reconfiguration of the magnetosphere as it has with solar wind energy flow across the magnetopause. The role of the IMF $B_z$, as ruminated by *Lennartsson* [1995], may be to influence that reconfiguration, via its effects on magnetospheric convection, rather than to "open and close" the magnetopause.

**References**

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