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Low-Energy ACR Spectra as Observed by the EPAC Investigation Aboard Ulysses

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Abstract

The EPAC investigation aboard Ulysses has provided low-background measurements of low-energy ACR ions since launch. In this brief report, we describe a few of these observations and compare them with some observations of other Ulysses investigations.

1 Introduction:

The Ulysses spacecraft has provided observations of ACR fluxes, or the lack thereof, in the inner heliosphere for almost a decade. The EPAC investigation measures CNONe fluxes from near the spectral peak (~7 MeV/nuc) down to a few hundred keV/nuc with very low background contamination. At energies of ~1 MeV/nuc and below, the major source of background has been ions accelerated by shocks of corotating interaction regions (CIR). We use measurements of He fluxes at those energies as an indicator of potential CIR contamination of the ACR measurements. We made a first report (Blake et al., 1994) of observations during the first southern pass of Ulysses; we found that above 4 MeV/nuc, the contamination of ACR measurements by CIR ions was nil. Fig. 1 shows an example of these results; the open squares are data acquired when EPAC observed no detectable He CIR fluxes, and the solid squares are data acquired for all but a few days of the greatest CIR and SEP fluxes. Tappen and Simnett (1996) also carried out CIR editing in their study.

2 Observations:

Fig. 2 shows a similar plot of the EPAC ACR oxygen fluxes for three different time periods over about four years. In order to make a direct comparison with the results of other Ulysses observations and because of page limitations, in this brief report we do not exclude CIR periods in the following figures. The first time period in Fig. 2 is the southern polar pass shown in Fig. 1; the second is during the northern polar pass; and the third was selected by Christian (1999) for a detailed study of ACR spectra in the inner and outer heliosphere. It can be seen that the ACR oxygen spectra remained quite constant, perhaps rising slightly at early times and falling at the end. The sharp rise below 1 MeV/nuc almost certainly is due to CIR ions.

Fig. 3 shows the CNONe spectra as observed by EPAC for the third time interval shown in Fig. 2. It can be seen from the sharp rise in the relative abundance of C, that below ~1 MeV/nuc, CIR ions dominate.

Fig. 4 presents published spectra for the southern polar pass from the Cospin (LET) and Hiscale investigations (Fisk et al., 1998), with the EPAC results plotted as well. While the agreement is not bad, the EPAC results indicate that the ACR energy spectrum fell below 6 MeV/nuc, whereas Hiscale indicates a flat spectrum. Note that the EPAC results given in Fig. 1 indicate that when CIR editing is used, the case for a falling spectrum becomes stronger.

Fig. 5 is the same type of plot as Fig. 3, but for the northern solar polar pass. In this case, the agreement between the EPAC and Hiscale results is excellent, whereas the LET observations indicate a rising spectrum.

3 Discussion:

The comparison of the observations by the three Ulysses investigations (EPAC, Hiscale, Cospin LET), although quite similar in overall results, do show significant differences. During the first southern polar pass, EPAC indicates that the oxygen ACR spectrum fell from a peak at around 7–10 MeV, whereas Hiscale does not, cf. Fig. 4. As noted in Fig. 1, we believe that there is contamination from CIR ions at the lowest energies if all time intervals are included in a spectral analysis. In the case of the northern polar pass, EPAC and Hiscale are in better agreement, whereas the LET results show a higher flux and a rising spectrum at their lowest energies.

Fig. 2 shows that the ACR fluxes below the spectral peak remained constant to within a factor ~3 over a wide latitude and radial range, and in both solar hemispheres for more than four years.

If the shape of the ACR spectrum below the spectral peak proves to be important for the theoretical analysis, removal of the time periods when significant CIR and SEP fluxes were present at Ulysses will give the most reliable results. Fig. 1 shows that during the first southern pass this is certainly the case.

References

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Christian, E. R. et al. Proc. 26th ICRC (Salt Lake City, 1999).

Fisk, L. et al., Sp. Sci. Rev. 83, 259, 1998

Tappin, S. J., and Simnett, G. M., ApJ 469, 402, 1996.

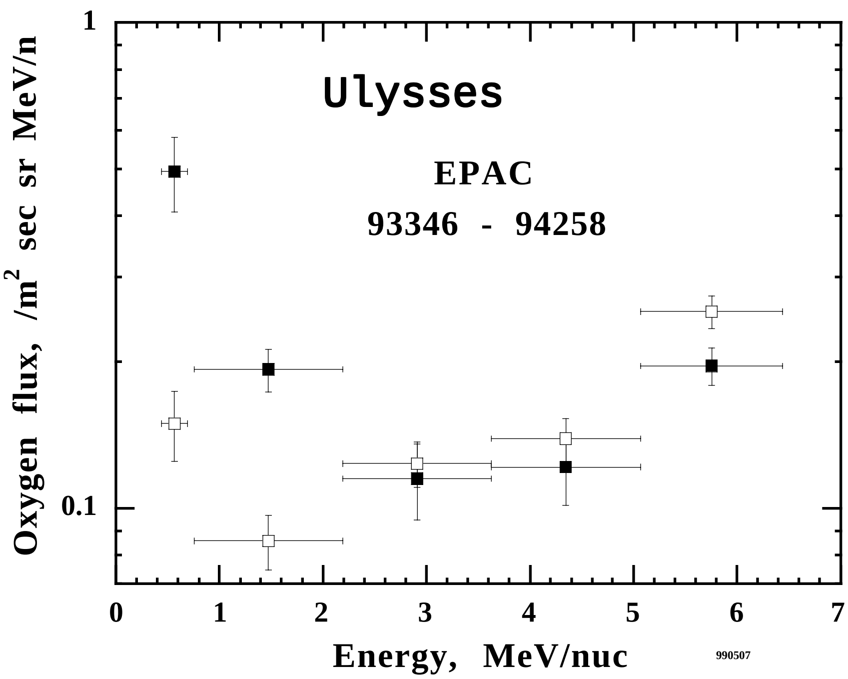

Figure 1. A comparison of oxygen spectra from EPAC with and without removal of time periods of significant CIR fluxes.

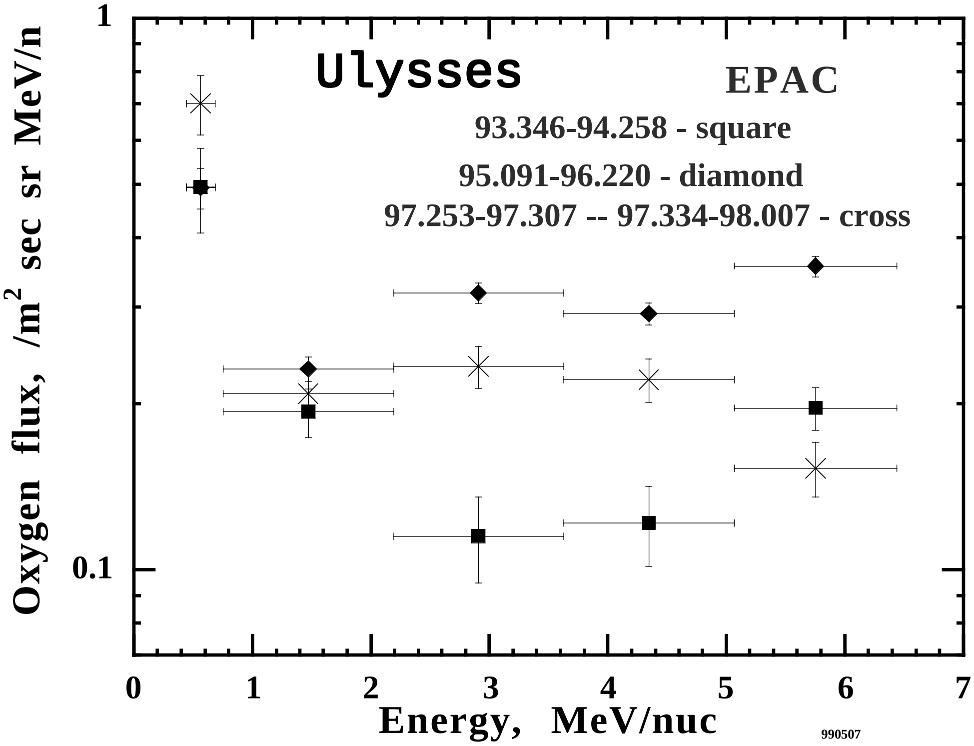

Figure 2. Oxygen spectra from EPAC plotted for three different time periods over a four-year period starting mid-1993.

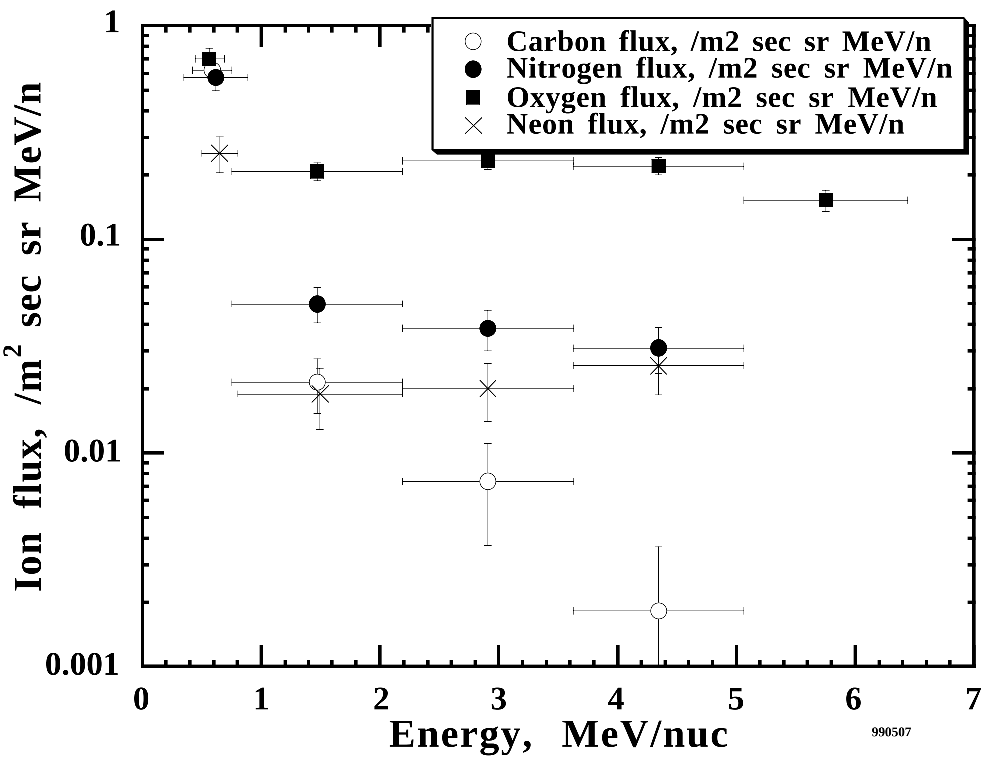

Figure 3. Spectra of CNONe ions from EPAC for a time period near the end of 1997.

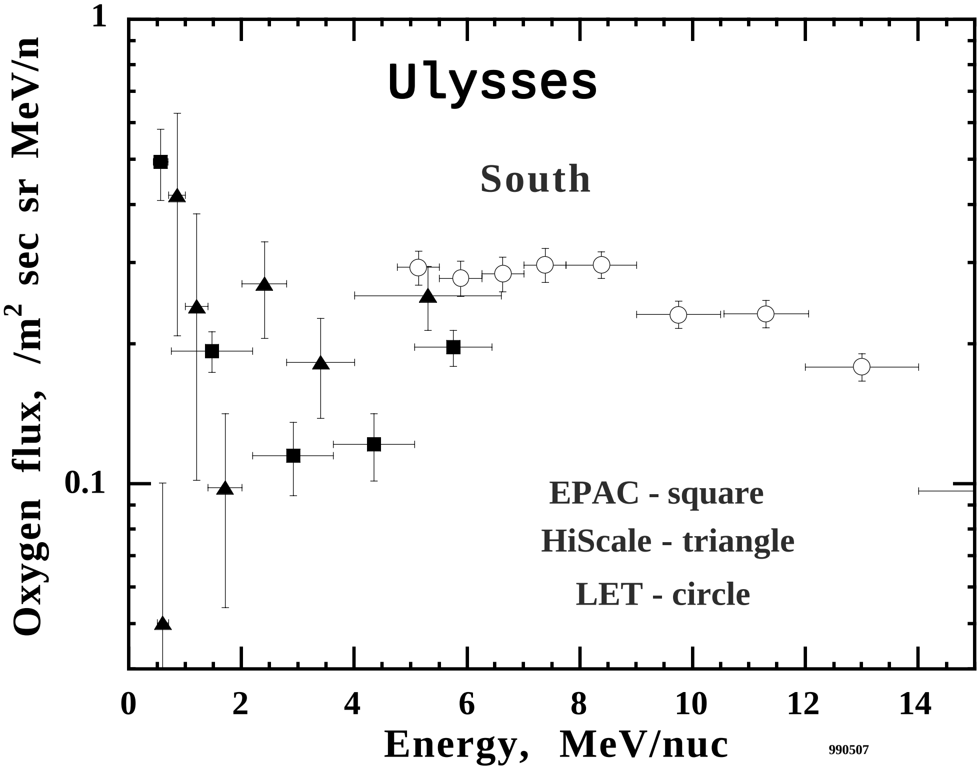

Figure 4. A comparison of EPAC, Hiscale, and Cospin-LET for the first southern Ulysses pass.

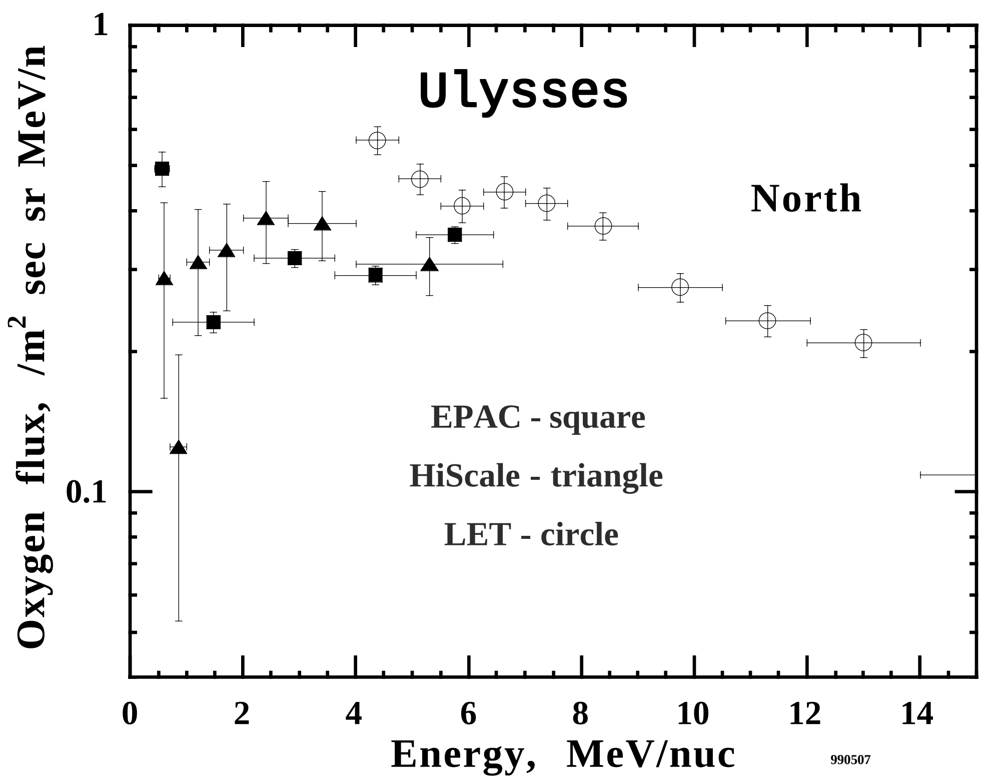

Figure 5. A comparison of EPAC, Hiscale, and Cospin-LET for the first northern Ulysses pass.