Solar Wind Charge Exchange as seen by XMM-Newton

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SWCX process, Robertson & Cravens modelling

\[ A^{q+} + B \rightarrow A^{(q-1)+*} + B^+ \]

\[ A^{(q-1)+*} \rightarrow A^{(q-1)} + h\nu \]
SWCX & the BGWG

• BGWG 1 – Steve Snowden presented HDFN 2004 case, proposed observation looking through nose of magnetosheath
• Kuntz & Snowden 2008 – particle bkg + SWCX
• Sun quiet at time – Snowden et al. 2009
• Leicester looked through sample of archive for SWCX affected observations - Carter & Sembay, 2008
  • Lightcurve analysis of a line (SWCX) band and a continuum band
Method

- Event lists flare-filtered using ESAS task mos-filter
- Resolved point sources removed
- Compare SWCX line band (0.5 – 0.7 keV) to continuum band (2.5 – 5.0 keV) lightcurve
- Deviation from a straight line fit: $\chi_\mu$
- Variation within each band, compute ratio: $R_\chi$
Current work – paper II in prep.

• Have extended to all Leicester archive, MOS full-frame
• Apply method as previously, identify SWCX cases
• Split identified observations into SWCX and SWCX-free periods
• Spectral model; model based on laboratory cross-sections concentrating on prominent SWCX lines. Applied to difference spectra of SWCX cases
• Line of sight analysis: modelling XMM-Newton orbit, magnetosheath under solar wind conditions
Preliminary results

- Top cases (most variability) are comets (green)
- Exospheric SWCX cases (red)
- Preferentially at beginning of mission
- Preferentially XMM-Newton found sunward of Earth
Example cases, temporally and spectrally

Line band
Cont. band
ACE

MOS1
MOS2

normalized counts s^{-1} keV^{-1}

residuals

Energy (keV)

1.68448 1.68450 1.68452 1.68454
Time (s x 10^5)

1.359002 1.359022 1.359042 1.359062 1.359102 1.35912
Time (s x 10^5)
Line of sight modelling

\[ P_{\text{X-ray}} = \alpha n_H n_{\text{SW}} \langle g \rangle \text{ (eV cm}^{-3} \text{ s}^{-1}) \]

- Dependent on ion species, neutral density, solar wind flux
- Solar wind data from OMNI (combined data from SW monitors such as ACE and Wind)
- Magnetopause location via Shue model, bow shock via Khan and Cowley
- Neutrals fall off with \( R_E^{-3} \) (limitation)
- XMM-Newton position and viewing angle from orbit files
- Charge exchange cross-sections included in term \( \alpha \)
- Model LOS in each time step and emissivity through the magnetosheath
LOS modelling examples
Conclusions & future aims

• About 5% of observations exhibit temporally variable SWCX
• Method does NOT identify cases where SWCX constant throughout the observations – need comparison of fields, e.g. Kuntz & Snowden 2008 etc.
• LOS modelling challenging – components of SWCX emission from inside and outside of bow shock (see Carter et al. 2010)
• Provide online 'SWCX likelihood' information for user, maybe in observation log browser
  • BGWG to decide where information useful