



The effect of spacecraft radiation sources on electron moments from the Cassini CAPS electron spectrometer

Christopher S. Arridge^{a,b,*}, Linda K. Gilbert^{a,b}, Gethyn R. Lewis^{a,b}, Edward C. Sittler^c, Geraint H. Jones^{a,b}, Dhiren O. Kataria^a, Andrew J. Coates^{a,b}, David T. Young^d

^a Mullard Space Science Laboratory, Department of Space and Climate Physics, University College London, Holmbury St. Mary, Dorking, Surrey, RH5 6NT, UK

^b The Centre for Planetary Sciences at UCL/Birkbeck, University College London, Gower St., London, WC1E 6BT, UK

^c NASA Goddard Space Flight Centre, Greenbelt, MD, USA

^d Southwest Research Institute, San Antonio, TX, USA

ARTICLE INFO

Article history:

Received 18 September 2008

Received in revised form

26 February 2009

Accepted 27 February 2009

Available online 6 March 2009

Keywords:

Cassini

Electrostatic analyser

Penetrating radiation

Moments

Noise subtraction

ABSTRACT

Data from the Cassini plasma spectrometer (CAPS) electron spectrometer (ELS) have been found to be contaminated with an energy-independent background count rate which has been associated with radiation sources on Cassini. In this paper we describe this background radiation and quantitatively assess its impact on numerically integrated electron moments. The general properties of such a background and its effects on numerical moments are derived. The properties of the ELS background are described and a model for the background presented. A model to generate synthetic ELS spectra is presented and used to evaluate the density and temperature of pure noise and then extended to include ambient distributions. It is shown that the presence of noise produces a saturation of the electron density and temperature at quasi-constant values when the instrument is at background, but that these noise level moments are dependent on the floating spacecraft potential and the orientation of the ELS instrument with respect to the spacecraft. When the ambient distribution has a poor signal-to-noise ratio (SNR) the noise determines the density and temperature; however, as the SNR increases (increasing primarily with density) the density and temperature tend to those of the ambient distribution. It is also shown that these noise effects produce highly artificial density–temperature inverse correlations. A method to subtract this noise is presented and shown to correct for the presence of the noise. Simulated error estimates for the density and temperature are also presented. The analysis described in this paper not only applies to weak background noise, but also to more significant penetrating backgrounds such as those in radiation belt regions of planetary magnetospheres.

© 2009 Elsevier Ltd. All rights reserved.

1. Introduction

The Cassini spacecraft, currently exploring the Saturn system is one of the largest and most complex interplanetary spacecraft ever launched and carries a comprehensive suite of remote and in situ instruments including an array of plasma science instrumentation. The Cassini plasma spectrometer (CAPS) suite comprises electrostatic analysers (ESAs) to analyse electrons between 0.5 eV and 26 keV and ions between 0.5 eV and 52 keV (with time-of-flight composition analysis for the ions), and an ion beam spectrometer for the study of narrow beams in the solar wind, magnetosphere, and in the vicinity of Saturn's moons (Young et al., 2004). The electron spectrometer (ELS) on CAPS is a top-hat

ESA very similar to the high energy electron analyser (HEEA) on the PEACE (Johnstone et al., 1997) instrument flown on Clusters I and II. Moments derived from CAPS/ELS data have been used in a variety of analyses (e.g. Young et al., 2005; Sittler et al., 2005; Hill et al., 2008) since Cassini's orbit insertion at Saturn.

The presence of a persistent energy-independent penetrating radiation background in the CAPS/ELS data has been described by Arridge et al. (2008) (manuscript in preparation) who concluded that radiation sources on the spacecraft (radioisotope thermoelectric generators, RTGs, and radioisotope heater units, RHUs) are the most likely origin for this penetrating radiation. The properties of this background are summarised in Appendix A. In this paper the effects of this noise on bulk electron parameters, determined by numerically integrating the observed spectra, are quantitatively examined. The effects of penetrating radiation in Saturn's radiation belts are not addressed but the analysis is sufficiently general that it may also be applied to such radiation backgrounds in future work.

* Corresponding author at: Mullard Space Science Laboratory, Department of Space and Climate Physics, University College London, Holmbury St. Mary, Dorking, Surrey, RH5 6NT, UK.

E-mail addresses: chris.arridge@physics.org, csa@mssl.ucl.ac.uk (C.S. Arridge).

Fig. 1 presents typical electron spectrograms and bulk electron parameters (density and temperature) measured by ELS inside Saturn's magnetosphere. Time–energy electron spectrograms are shown in two systems of units to illustrate how the background noise is expressed in the data. Panel 1a shows data in counts/s which is essentially uncalibrated except from being corrected for gain, instrument accumulation time and dead-time. Panel 1b shows the same data but in calibrated units of differential energy flux (DEF), calculated from the former spectrogram by dividing the count rate R by the instrument's geometric factor ($G(E)$, in energy units). The electron fluxes vary throughout the interval and exhibit minima at approximately 10:00 and 20:00, reaching the noise level across all energies in the latter interval.

It can be seen from panels 1a and b that the electron flux increases with increasing energy, even when the instrument is at

the noise level. This behaviour is produced by the shape of the ELS geometric factor, which is approximately constant at energies less than ~ 100 eV but decreases with increasing energy thereafter. The presence of an ambient electron distribution modulates the behaviour of the electron flux and can be seen in data near 10:00 where two distinct peaks are seen in the calibrated spectrum; one due to the real population near 100 eV, and a second artificial peak caused by the background noise at high energy. It is also important to point out that this high-energy high-flux bias is modulated by the telemetry mode of the instrument (shown in panel 1e) and can be seen most clearly in modulations in the scatter of the electron temperature after 20:00.

Turning our attention to the bulk parameters in panels 1c and d we see that when the overall electron flux drops, the ELS density

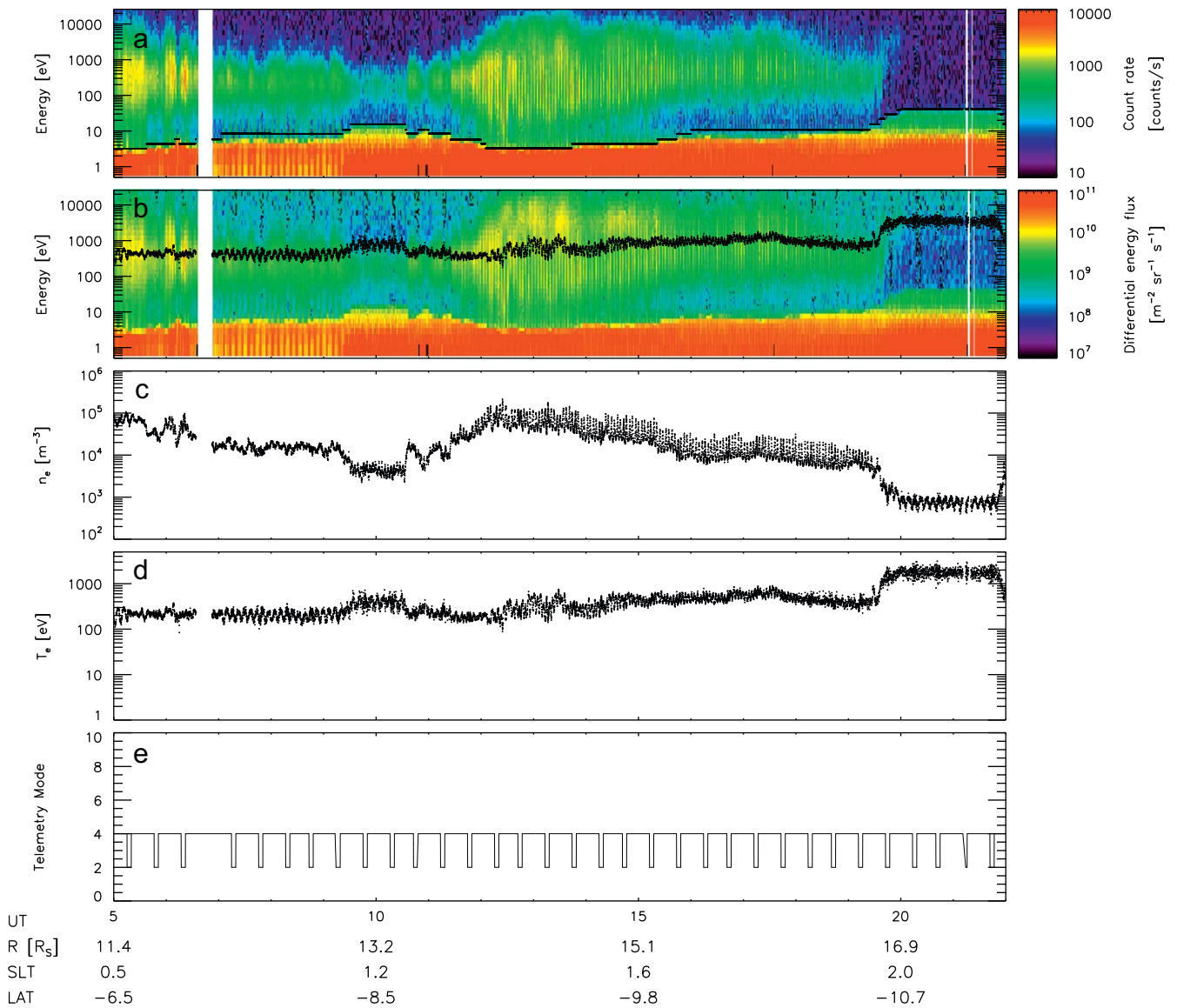


Fig. 1. Time–energy electron spectra and electron bulk parameters, measured on 20 January 2006, illustrating the effect of changes in density on numerically integrated moments. Panels (a) and (b) contain spectrograms in counts/s and differential energy flux, respectively. Panel (c) contains electron number density, (d) electron temperature, and (e) presents the telemetry mode for the instrument. Both spectrograms are dominated below 10–20 eV by trapped spacecraft photoelectrons and there is an increase in flux in the higher energy channels in panel (b). Overlaid on panel (a) is the floating potential of the spacecraft. Overlaid on panel (b) is the $2k_B T_e$ where T_e is the electron temperature from panel (d)—for a Maxwellian the peak in the distribution should lie along this curve. In regions of high flux this is generally the case, but in low flux this does not hold—this is particularly evident beyond 20:00 and shows that the electron temperature is overestimated in this region.

Download English Version:

<https://daneshyari.com/en/article/1781889>

Download Persian Version:

<https://daneshyari.com/article/1781889>

[Daneshyari.com](https://daneshyari.com)