LULEÅ UNIVERSITY OF TECHNOLOGY
V. Barabash / 2016

F7003R Optics and Radar Based Observations, 7.5 ECTS

Problems Optics (5 points)

Topics for work and examination

Basic radiometric concepts. Method to estimate the irradiance at the image plane of an optical system.

Estimation the number of photons at the image plane, at the detector and at a pixel. Definition of quantum efficiency. The charge coupled device (CCD). CCD performance. Estimating the number of photoelectrons reaching a pixel. SNR. Overview CCD noise sources. SNR for a CCD.

Optical system, interference filters, camera positioning system.

Overview of image intensifiers. ISSD. Estimation of SNR for ISSD. Definition of threshold of detection, noise equivalent exposure (NEE), saturation equivalent exposure (SEE) and dynamic range.

Scientific applications.

Materials for work:

- U. Brändström, The Auroral Large Imaging System – Design, Operation and Scientific Results, IRF Scientific Report 279, 2003, ISSN: 0284-1703, ISBN: 91-7305-405-4.
  http://www.irf.se/~urban/avh''
  file "U. Brändström ALIS IRF report.pdf"

- Höymork S. et al., Sensors and Instruments for Space Exploration, compendium 3rd edition, Swedish Institute of Space Physics, Kiruna, 2002.

- Articles available on Canvas

Additional:

- Holst, G. C., CCD arrays, cameras and displays, 2nd ed., The International Society for Optical Engineering, 1998, ISBN: 0-8194-2853-1.
- Howell, S. B., Handbook of CCD Astronomy, Cambridge University Press, 2006, ISBN 0-521-61762-6.

1 (0.5 points)

Discuss the main working principles of a charge coupled device (CCD).

2 (1 point)

Define and give an overview of the following parameters of the CCDs:

- spectral radiant incidence;
- number of incident photons;
- quantum efficiency;
- pixel;
- noise and its sources;
- signal-to-noise ratio for CCD and image intensifier (ICCD);

- noise equivalent exposure (NEE) and saturation equivalent exposure (SEE);
- dynamic range.

3 (1 point)
Discuss technical specifications of CCD elements for Auroral Large Imaging System (ALIS):
- optical system;
- interference filters,
- camera positioning system.

4 (1.5 points)
Discuss the main scientific results achieved with ALIS related to:
- estimation of auroral electron spectra;
- auroral vorticity;
- ionospheric trough;
- daytime auroral imaging;
- auroral events and thermospheric neutral wind;
- meteor studies.

To answer this question you are advised to use the scientific report of U. Brändström. Otherwise you are addressed to the Bonus question.

5 (1 point)
Consider the ground based CCDs used on ALIS and the on-board CCDs for Earth auroral imaging (files "INDEX camera.pdf", "REIMEI camera.pdf", "REIMEI camera2.pdf"). Compare their technical requirements, analyse technical and practical advantages as well as disadvantages of the experiment, discuss the obtained results.

Bonus (2 points)
The answer to the Question 4 is related to the scientific results available until 2003. Perform a literature survey of two topics for their updating. The results might not be related to the ALIS system.
Note: you are advised to use the international databases available via LTU Library Learning Center http://www.ltu.se/ltu/lib/Soka/Databaser-artiklar-m-m?l=en