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MULTI-SCALE AURORAL OBSERVATIONS IN APATITY: WINTER 2010-2011

B.V. Kozelov, S.V. Pilgaev, L.P. Borovkov, V.E. Yurov (*Polar Geophysical Institute, Apatity, Murmansk region, 184209, Russia*)

Abstract. Routine observations of auroral structures are provided in Apatity by set of five cameras: (i) all-sky TV camera Watec LCL-902 (1/2" CCD) with Fujinon lens YV2.2×1.4A-SA2; (ii) two monochromatic cameras Guppy F-044B NIR (1/2"CCD) with Fujinon HF25HA-1B (1:1.4/25mm) lens for 15^o field of view and glass filter ~558 nm; (iii) two color cameras Guppy F-044C NIR (1/2"CCD) with Fujinon DF6HA-1B (1:1.2/6mm) lens for 60^o field of view. The observational complex is mainly aimed to study of spatial structure of aurora, scaling in auroral structures, and vertical distribution in rayed structures. The cameras were installed at the main building of Apatity division of PGI and at Apatity stratospheric range. The distance between these points is 3850 m, so the identical monochromatic cameras can be used as a stereoscopic system. All cameras are accessible and operated remotely via Internet. For 2010-2011 winter season the equipments were upgraded by special blocks of GPS-time triggering, temperature control and motorized pan-tilt rotation mounts. The report presents the equipments details, overview of observed events and web-site with access to available data previews.

1. Introduction

The aurora is one of the most spectacular events in Nature. While the main physical processes lead to the auroral luminosity are known, there is no theory to explain whole variety of auroral structures. Moreover, there is no conventional conclusion about such important for plasma physics characteristic of aurora as a minimum (or typical) width of auroral arcs and filaments [Maggs and Davis, 1968; Borovsky, 1991; Sandahl et al., 2011]. Many authors concluded that the results strongly depended on instrumentation details: field of view and sensitivity of auroral camera, filters, distortions, ets. [Knudsen et al., 2001; Dahlgren et al., 2008]

Last years the new ideas of turbulence and self-organized criticality originally developed for description of the plasma complexity were applied for explanation of the auroral structures [Uritsky et al., 2002; Kozelov, 2003; Kozelov et al., 2004; Kozelov and Rypdal, 2007]. These approaches based on statistical distribution and to obtain them we need to utilize information about auroral luminosity in wide range of spatial scales. The only way to obtain this information is simultaneous observations by cameras with different field of view. So in addition to traditional all-sky cameras we need to provide the observations by cameras with narrow field of view directed to magnetic zenith where the smallest scales can be better resolved.

The aspect angle distortion (the perspective effect) is an additional problem which appears before investigators of the auroral structure. There are two ways to take it into account: (i) incorporate it to the statistical model of the data analysis (see, for example, [Kozelov and Golovchanskaya, 2010]), and (ii) to exclude it by tomography reconstruction [Gustavsson, 1998]. In the last case the simultaneous observations from spatially separated points are needed.

Here we present a low-cost observational system which realizes the requirements mentioned above. The complex was started in 2008 from one digital camera shared by prof. Torsten Aslaksen (Universitu of Tromso, Tromso, Norway) for winter 2008-2009. After that season we recognized a possibility of the auroral observations by the low-cost digital cameras and started to build the system. The report presents the equipments details actual for the 2010-2011 winter season, examples of observations and web-sites addresses to access to the data previews.

2. Equipments

A schema of the observational system is shown in Fig.1. Four cameras were operated automatically during dark time independently on weather conditions. The main characteristics of the cameras are summarized in Table 1. The cameras were installed at the main building of Apatity division of PGI and at Apatity stratospheric range. More information about the cameras available at vendor's web-sites http://www.alliedvisiontec.com and http://www. wateccameras.com .

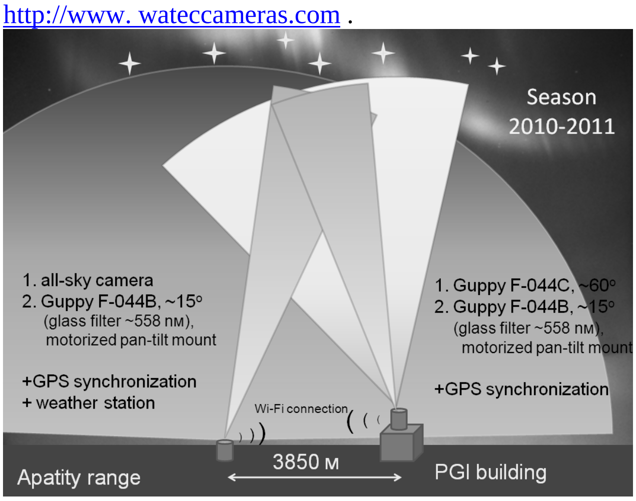

Fig. 1. Location of the cameras during 2010-2011 winter season.

Table 1. Characteristics of the auroral cameras.

#	Camera	Interface	Lens	FoV	Position	Data resolution	Operation time
1	Watec LCL-902	Analog video with frame grabber	Fujinon YV2.2×1.4A-SA2	180°	67.34°N, 33.18°E	232x232, 16 bits, 1 s (24 integrated frames)	Dec 28, 2010 – Apr 14, 2011
2	AVT Guppy F-044B NIR	IEEE 1394a	Fujinon HF25HA-1B, glass filter ~558 nm	15 °	67.34°N, 33.18°E	376x288 pix, 8 bits, 1 s	Dec 28, 2010 – Apr 14, 2011
3	AVT Guppy F-044B NIR	IEEE 1394a	Fujinon HF25HA-1B, glass filter ~558 nm	15 °	67.34°N, 33.24°E	376x288 pix, 8 bits, 1 s	Oct 20, 2010 – Apr 14, 2011
4	AVT Guppy F-044C NIR	IEEE 1394a	Fujinon DF6HA-1B	60°	67.34°N, 33.24°E	376x290 pix, 4 colors (CMY+G), 8 bits, 1 s	Oct 20, 2010 – Apr 14, 2011

The narrow field of view cameras were mounted on industrial pan-tilt motorized mounts to fit direction of observation. All cameras were directed to a region near the magnetic zenith. The distance between the points of observation is 3850 m, so the identical monochromatic cameras can be used as a stereoscopic system.

All cameras, data storage computers and motorized mounts are remotely accessible and operated through INTERNET.

A special module was developed for precise time synchronization: for triggering of the image capture by cameras, for time synchronization of the data storage computers, and also for collection of information from temperature sensors in housing boxes and for operation by the mounts' motors. The module based on industrial Lassen SK II GPS Module (see more details here: http://www.prin.ru/equipment/gps_modules) completed by original microcontroller. The schema of the synchronization module is shown in Fig.2. The modules were installed in both points of observations to avoid possible interruptions in Wi-Fi connection between them. The estimated precision of the time synchronization for simultaneous images is better than a few milliseconds, that is a good precision for auroral observations.

One more camera (#5) was manually operated during good weather conditions. This camera was the same as number 4 in Table 1, but located at position 67.33°N, 33.25°E and usually directed in the Nord. The intervals of observations are available here: http://sites.google.com/ site/auroraobservations/ .

3. Results of observations

The data storage from cameras #1-4 was provided by original Linux-based programs. Real time images from the cameras were available on-line at web-site http://db.pgia.ru/cam/. The images were stored at the hard disks and prepared for web-archive. Automatically generated web-archive for each camera contains of monthly overviews, daily and hourly keograms, and individual images in JPG format with 10-s resolution. Original uncompressed frames are available by request.

Unfortunately due to weather conditions and low solar activity during 2010-2011 winter there were a few days of aurora observation near zenith in Apatity. One of them was a day of magnetic storm on February 4. Fig. 3 presents an example of auroral structures observed simultaneously by the camera set during this event.

On-line journal of the hardware modifications is placed at web-site http://sites.google.com/site/auroraobservations/. The same site contains the keograms from North-directed color camera (#5), where the aurora activity were observed more often, practically during all nights with good enough weather conditions.

Conclusions

A new optical system for routine observations of auroral structures has been installed in Apatity. The observation system gives information about auroral structures in 3 different fields of view: all-sky (180°), 60° and 15°. Two spatially separated identical cameras gives us possibility to use its images as a stereoscopic pair and extract information about the auroral structure in the plain perpendicular to the magnetic field lines.

The web-preview archive is accessible for selection of events. The data analysis and observations will be continued in next winter season.

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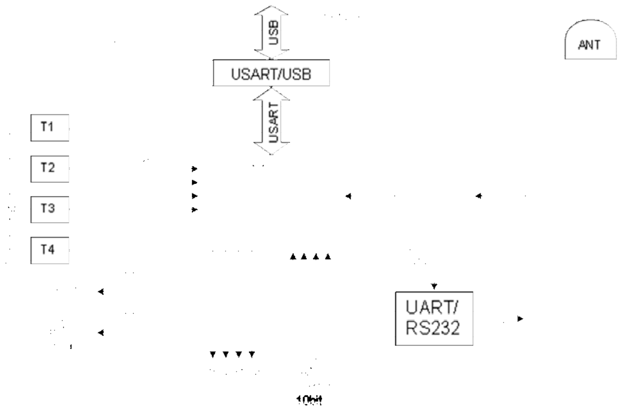

Fig. 2. Schema of synchronization module.

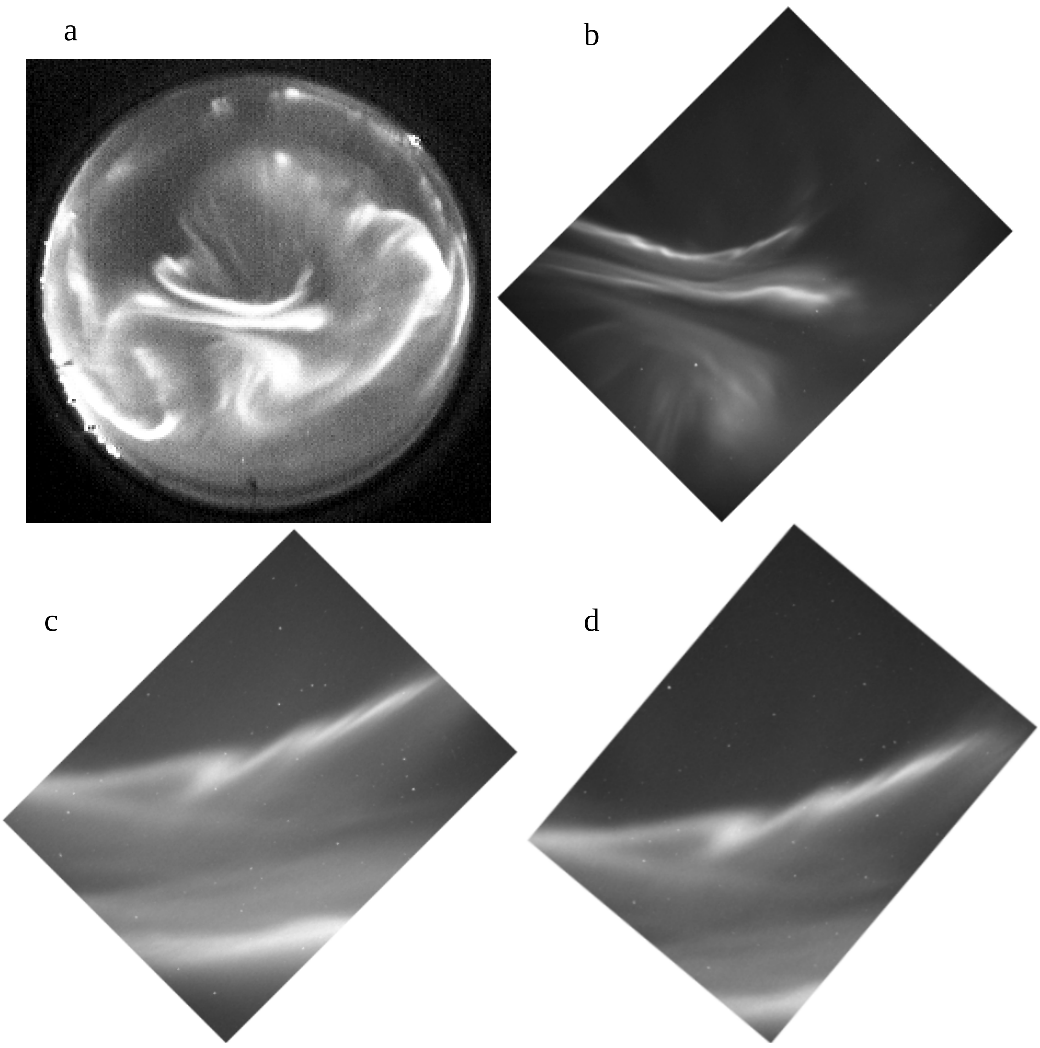

Fig. 3. Simultaneous observation by four auroral cameras described in Table 1 on February 4 at 18:16:51 UT. a – all-sky; b – 60^o; c – 15^o (PGI building); d – 15^o (Apatity range).

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