IMAGING OF FINE STRUCTURE IN HEATER-INDUCED AIRGLOW ABOVE THE HAARP HF TRANSMITTER

E. A Gerken[(1)], U. S. Inan[(2)]

[(1)]Space, Telecommunications and Radioscience Laboratory, Stanford University, STAR laboratory, Stanford University, Stanford, CA 94305-9515; E-mail egerken@.stanford.edu

[(2)]As (1) above, but E-mail inan@nova.stanford.edu

ABSTRACT

A telescopic imaging system developed by Stanford University was used to conduct artificial airglow measurements at the High Frequency Active Auroral Research Program (HAARP) in Gakona, AK. Either 630nm or 557nm airglow was observed on thirteen nights during the February 2002 campaign by the telescope imager and other participating cameras at HAARP, Poker Flat Research Range, and the HIPAS heating facility. The February 2002 campaign was the first dedicated optical campaign at HAARP. Data from the telescopic imager in conjunction with the other cameras, digisonde, riometer, and magnetometer is presented from pulsing, continuous mode, and power ramping transmissions.

INTRODUCTION

Stanford University has conducted several campaigns to make telescopic measurements of optical emissions artificially induced by heating the ionosphere using a high power, high-frequency (HF) phased array radio transmitter at the High Frequency Active Auroral Research Program (HAARP) in Gakona, Alaska (62.39N, 145.15W). With a narrow field of view (0.72 degrees x 0.9 degrees) the telescopic system is able to determine whether there is fine structure in the optical airglow emissions and can view an object 200km away with a resolution of ~6m. Although observations of heater-induced airglow have been conducted in the past both at HAARP [1] and other heating facilities [2], [3], [4], our observations are the first attempt to look for fine structure within the heated regions. Observing either the absence or presence of structure is an important scientific contribution and gives additional insight into the atmospheric makeup of these heated regions. Although the main lobe of the HAARP HF heater is quite broad, one might expect fine structure due to ambient electron density variations. It is also possible that small variations in the radiation pattern within the main lobe may be detectable. The large aperture of the telescope additionally enables this system to make very sensitive measurements of airglow brightness in the center of the heated spot. Campaigns were conducted in March 2000, October 2000, March 2001, and February 2002. In this paper data is presented from the February 2002 campaign in which artificial airglow was observed.

EXPERIMENT DESCRIPTION

The imaging system consists of a telescope with a cooled scientific bare CCD camera mounted at the image plane of the telescope. The system uses a Meade Starfinder telescope which is a 16" aperture, f/4.5 Dobsonian-mounted, Newtonian reflecting telescope. The camera is narrowband-filtered to allow either the near infrared N2 first-positive lines, the 630nm oxygen line, the 557.7nm oxygen line, or the hydroxyl lines to be selected for viewing. The camera is a Princeton Instruments VersArray 512B digital CCD system with thermoelectric Peltier cooling, 512X512 pixel format, and binning and subregion readout modes. Frames from the camera are sent directly to a computer interface with accompanying software for real-time acquisition, display, and data processing. The interface has a 16 bit A/D converter with dual speeds of 100kHz and 1MHz. The camera is integrated for several seconds in order to be able to view the relatively dim airglow levels of 20-100 R. An intensified CCD video rate wide field of view camera (~12x9 degrees) camera is mounted on the telescope in order to monitor environmental conditions such as aurora and clouds overhead.

RESULTS FROM THE FEBRUARY 2002 CAMPAIGN

This experiment was conducted during several fall/spring campaigns in 2000-2002. Airglow was observed in the March 2001 campaign and the February 2002 campaign. In the February 2002 campaign 630nm and/or 557.7nm airglow was observed on 13 out of 19 nights of observations. In addition to the telescopic imaging system, the HAARP all-sky imager (operated by the Air Force Research Laboratory) and a Naval Research Laboratory 60 degree field of view imager also observed the airglow at HAARP. Cameras were set up at Poker Flat Research Range (University of Alaska,

Fairbanks) and the HIPAS heating facility (University of California, Los Angeles) in order to image the airglow from side views and make volume and altitude measurements. Digisonde, riometer, and magnetometer measurements were conducted at HAARP as part of the permanent diagnostic system at the facility. Several transmission schedules were run in order to probe the airglow mechanism by sweeping the beam position, varying the transmitted power, pulsing the transmitter, and modulating the heater frequency. It was determined during this campaign that the airglow at HAARP reaches maximum brightness at magnetic zenith and so the telescope was aimed in this direction for the majority of the campaign. One transmission run was five minute on/ five minute off, full power, O-mode at a heater frequency near foF2 and aimed at magnetic zenith. Airglow observations during this transmission show that the airglow reaches maximum brightness with a characteristic rise time after the heater is turned on and similarly a characteristic decay time when the heater is turned off. The heater was also operated in a continuous wave (CW) mode and it was found that the airglow brightness oscillates in time. During one CW run the decay in airglow brightness was recorded as foF2 dropped below the heater transmitted frequency. A power ramping transmission was run in which the transmitted power was incrementally varied from 1kW/transmitter up to 10kW/transmitter and back down again. The airglow brightness tracks the increase and decrease in power and was observed even at the lowest power levels.

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