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Development and evaluation of the drive system of InSb imager mounted on infrared cameras for Jovian aurora

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In Tohoku University, infrared observation system is being developed for self-owned 60cm telescope. The purpose of this research is to develop a driving system of a Focal Plane Array (FPA) mounted on both an infrared camera and Echelle spectrometer and to evaluate observation possibility for various specific objects by establishing a method to determine adequate operating conditions based on detailed evaluation and analysis of a FPA.

First, from the previous researches, we estimated the required S/N to reveal the variation of some specific Jovian objects. In the case of H3+ aurora, the required S/N and the limit imaging time are 15 and 15s, respectively. For H2 aurora, they are 5 and 1200s. For equatorial temperature field, they are 5 and 7200s. Based on these, we showed the noise indicator, is composed of an upper limit of read noise and leakage current of FPA to realize the required S/N, considering the emission from a telescope and terrestrial atmosphere, and object.

Next, based on the driving mechanism of the FPA: CRC463(Raytheon) used in this research, we revealed that adequate bias is under -3.0V:Vdet, and over -4.0V :Vdduc. In this condition, Full Well(FW) is increased from 0.02V to 0.4V when bias(Vdet-Vdduc) is set at 0.6V, and we succeeded in the imaging of halogen lamp. And, we made improvements as follows.1. Increasing of conductivity of thermal path in the IR camera. This successfully decreased the temperature near FPA from 45K to 20K, resulting in the decrease of both the leakage current from 17,145e/s to 200e/s and the read noise from 453e$_{rms}$ to 320e$_{rms}$.2. Verifying the specific problem on CRC463, and we suggested new driving sequence based on frame to frame control. This resulted in the decrease in the read noise (to 200e$_{rms}$). This made it possible to precisely evaluate the performance of this system.3. Improving bias circuit in FPA driving system. The noise in output was reduced, resulting in the decrease of read noise (to 90e$_{rms}$).

Thanks to the above, it became possible to evaluate the performance parameters of FPA by Photon Transfer Curve method. As the result, in the case of 0.6V bias, DSNU and PRNU were evaluated as 38 ‰ and 16 ‰, respectively. In addition, leakage current, FW and system gain were 200e/s, 133,000e, and 10.9e/DN. We confirmed that the quantum efficiency is 0.85. We also evaluated the NEDT. With a 2.3μm filter and incident flux of 400K of blackbody, the NEDT reaches 45mK, is the equivalent performance compared to the third generation FPAs. As well, the performance parameters of our system other than the leakage current are equivalent to those of the NASA's IRTF system using the same FPA.

And, we evaluated the bias dependences on FW, leakage current and system gain. Using the results, we established the method to determine the adequate bias setting to realize the maximum S/N for specific object. As a result, following estimations were obtained. Using this FPA driving system, H3+ aurora can be observed at the maximum S/N=30 when the bias and exposure time are set at 0.5V and 15s. In the case of H2 aurora, the maximum S/N is 3.14 after binning, when the bias and imaging time are 0.4V and 1200s, respectively. Obtained S/N is below the requirement. It is needed to decrease leakage current under 81e/s. The case of temperature field, the maximum S/N is 52.7 with accumulating 28times, when total imaging time is 7200s, and the bias is set at 0.4V. To decrease accumulating times, bias should be set at 0.9V. If the leakage current will be under 100e/s, the S/N will be over 40 with an accumulation.

In summary, we developed FPA driving system for IR observation instrument mounted on telescope of Tohoku University for planetary observation. We evaluated the performance in detail, and developed the method to determine the adequate bias conditions for each observational object. Decreasing the leakage current is the remaining issue since it is two orders of magnitude larger than the FPA ' s specification.

Keywords: Focal plane array drive system, IR telescope of Tohoku Univ., long-term observation for planet, NASA IRTF