HIGH RESOLUTION OBSERVATIONS OF ACTIVE AND PASSIVE THERMAL EMISSION FROM ENCELADUS' SOUTH POLE IN 2015: THE CLOSEST AND THE COLDEST.

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Introduction: Cassini's last targeted flybys of Enceladus occurred in late 2015. Two of these, E21 and E22, provided good views of the active south pole. On both these flybys, the Composite Infrared Spectrometer (CIRS), a thermal IR Fourier transform spectrometer on the Cassini spacecraft [1] obtained high-resolution observations of the endogenic and passive (re-radiated sunlight) thermal emission from Enceladus' tiger stripes and their surroundings, CIRS has three focal planes sensitive to different wavelength ranges: "FP1" 16 – 500 µm (20 – 600 cm^{-1}); "FP3" (9 – 17 µm, 600 – 1100 cm^{-1}); and "FP4" (7 – 9 µm, 1100 – 1500 cm^{-1}). FP1 consists of a single detector with 3.9 mrad IFOV, while FP3 and FP4 each have a linear array of 10 detectors with IFOV 0.29 mrad. Here we report on the CIRS observations made during these flybys, and some very preliminary results. Additional details will be provided at the conference.

E21: This flyby occurred on Rev 224 on October 28th 2015, at the very low altitude of 48 km, providing the highest spatial resolution data on the tiger stripe thermal emission that Cassini will ever obtain. The low altitude and short time available precluded normal pointed spectroscopic observations (the active tiger stripe region was traversed in about 12 seconds, compared to the minimum CIRS integration time of 5 seconds). Therefore, high-resolution mapping was done in an unusual way, first used with lower temporal resolution on the E18 flyby in April 2012 [2, 3], by exploiting the 5 msec sampling of the CIRS raw interferograms. Spacecraft orientation was inertially fixed, and chosen so that several tiger stripes, including the most active part of Damascus Sulcus, passed through the CIRS field of view during the flyby. The FP3 and FP4 detectors were operated in pairs, giving five cross-track spatial resolution elements, each 28 meters wide, in each focal plane. Along-track spatial sampling, defined by the 5 msec interferogram sampling time and the flyby speed of 8.5 km/sec, was ~40 meters. At longer wavelengths, CIRS obtained a single-detector ("FP1") interferometer scan.

All CIRS detectors obtained strong signals when crossing the tiger stripes (e.g. Fig. 1). These do not represent flux directly, but can be inverted, accounting for the instrument response, to obtain unique constraints on the spatial structure of the thermal emission. Interferogram structure varies considerably between spatially adjacent detectors, implying rich spatial structure on scales of tens of meters.

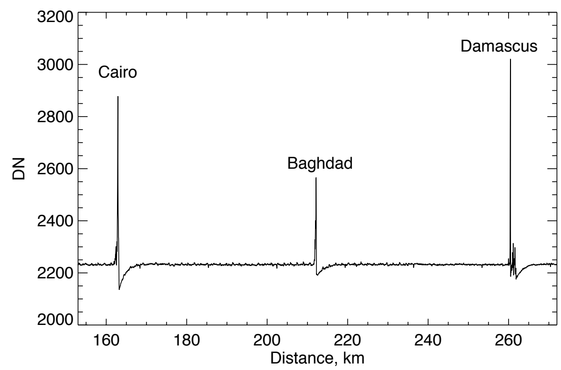

Figure 1 *Raw interferogram from one of five paired detectors of the CIRS FP3 focal plane from the October 28th Enceladus south polar flyby, showing strong spikes due to passage of the field of view across the 9 – 17 µm thermal emission from Cairo, Baghdad, and Damascus Sulci. These interferograms can be inverted to determine the spatial distribution of the thermal emission at tens of meter scales. Similar interferograms were obtained with the FP4 and FP1 detectors.*

E22: This flyby, Cassini's final close Enceladus flyby, occurred on Rev 228 on December 19th 2015 at an altitude of 4999 km. At this range, it was possible to obtain several hundred conventional spectra of the south pole over a period of about 30 minutes centered on closest approach, with spatial resolution as good as 1.5 km in FP3 and FP4, and 20 km in FP1.

A prime goal of the E22 flyby was to better constrain the heat flow from the south pole by observing long-wavelength emission with the FP1 detector (where most endogenic emission is radiated [4, 5]), at spatial resolution sufficient to separate the emission from the tiger stripes from that of their surroundings, at a time when the south pole had been in winter darkness for 6 years, minimizing passive thermal emission. Data can be compared to similar data obtained shortly after equinox in 2010 [5], to constrain surface cooling and improve understanding of the spatial distribution of the heat flow. Two scans were obtained: Fig 2 shows a preliminary reduction of one of these scans. We will report on the implications of these data for Enceladus' heat flow.

In addition, CIRS obtained FP3 and FP4 scans of the brightest part of Damascus Sulcus at closest approach, which will provide improved knowledge of the spatial and temperature distribution of the high-temperature component of the tiger stripe thermal emission, and its temporal variability since the last high resolution observations of the same area taken in 2010.

References: [1] F.M. Flasar et al. (2004), *Space Science Rev*. **115** 169–297. [2] J.R. Spencer et al. (2012), *DPS meeting #44,* id.#104.06. [3] N.J.P. Gorius, et al. (2015), *DPS meeting #47*, id.#410.01. [4] C.J.A. Howett et al. (2011), *J. Geophys. Res.* **116**, CiteID E03003. [5] J.R. Spencer et al. (2013), *2013 EPSC meeting* EPSC2013-840.

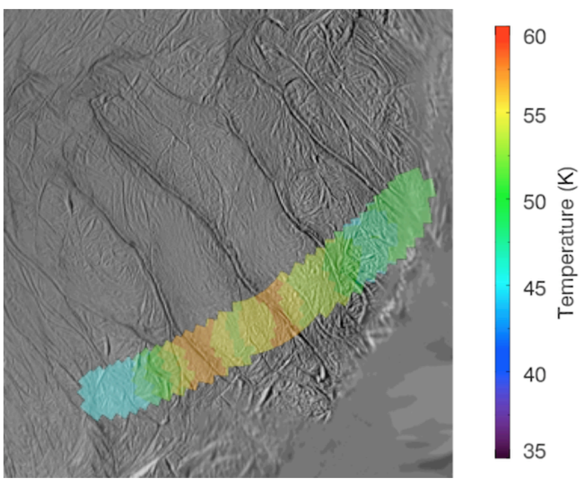

Figure 2 *Preliminary reduction of a CIRS FP1 scan of the tiger stripe region during the E22 flyby, showing the brightness temperature of the resolved 6 – 200 µm emission from several of the tiger stripes.*