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Supporting Information for

UVS Observations of Ganymede's Aurora During Juno Orbits 34 and 35

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Introduction

In Text S1 we describe the approach we took to make a minor adjustment to the spin phase of the Juno Spacecraft contained within the reconstructed spice kernels to correct the mapping of auroral emissions observed by Juno UVS during the PJ34 close flyby of Ganymede. The temporal shift required is in agreement with mapping efforts of the SRU team [Becker et al. this journal]. Figures S1 to S6 are in support Text S1.

Figure S7 shows the PJ35 Ganymede flyby observations in a similar fashion to Figure 1 in the main text without the visible image backdrop.

Text S1.

Mapping of the Juno UVS data relies upon reconstructed trajectory information captured within NAIF spice kernels [*Acton*, 1996]. The Juno UVS dataset retrieved during the PJ34 flyby of Ganymede had a temporal sampling resolution of 8 ms or 0.096° of Juno spin phase. Using the NAIF spice toolkit, we produced brightness maps of the integrated oxygen emission lines observed at 130.4 and 135.6 nm observed over Ganymede's disk. Initial mapping, relying purely on the spice kernels and mapping the integrated oxygen brightness to the surface of Ganymede, resulted in the map shown in Figure S1. While the northern auroral emissions in this image appear to form a smoothly varying auroral curtain in both latitude and longitude, the southern auroral emissions appear to have a cusp or kink in the mapping near -50° west longitude and -15° latitude.

This morphology was unexpected and is hard to explain physically. Given that and the fact that the southern emissions were observed very close to the southern observable limb of Ganymede as seen from Juno during the flyby, a possibility was either the mapping was being performed at the wrong altitude (the auroral emissions were produced not at the surface but at some higher altitude) or there was a small error in the spin phase of the Juno spacecraft within the reconstructed kernel files causing the mapping of emissions observed just off the limb of Ganymede to be accidentally mapped onto the surface. To test the first hypothesis, we reran our mapping routines and mapped the auroral emissions to altitudes of 0 (surface), 50, 100, and 200 km. The results of the 50 km altitude test are shown in figure S2. As can be seen, by mapping the auroral emissions to a higher altitude the observed discontinuity in the south got more severe and in general all of the auroral emissions (north and south) are seen to map more equatorward than they did when they were mapped to the surface. This is as expected geometrically and these same effects are seen at 100 and 200 km to even greater extents. Thus, it appeared that the altitude mapping was not the cause of the odd discontinuity in the southern auroral oval structure. We then tested small time shifts in the spin phase of the spacecraft to see if that would remove the discontinuity seen in the southern oval. We did this by adjusting all the time fields used within the UVS level 3 dataset by time shifts of 35, 0 (nominal case), -17, -35, and -70 ms, and leaving the reconstructed spice kernels alone with their nominal solution. Surface maps of the emissions at these temporal offsets are shown in figures (S3, S1, S4, S5, and S6, respectively). It can be seen that the discontinuity is enhanced if the temporal shift is positive (S3), but that a negative temporal shift of merely 35 ms is enough to push the emissions in the kink off the surface map (moving them to off limb emissions as seen from Juno) and removing the odd kink in the auroral emissions from the Ganymede map. Further confidence supporting the need for a temporal shift was given by SRU imaging of the Ganymede surface. Their observation had many surface features which the SRU team could compare to historic surface maps. Their comparison of the SRU image and the surface maps required a -34 ms temporal shift (shift in the spin phase) to align the observed features to those previously mapped. Thus, we have multiple lines of evidence calling for a temporal shift correction of the reconstructed kernels in spin phase of ~35 ms for the mapping of the PJ34 Ganymede flyby dataset, and we use this shift for the PJ34 data shown in our paper.

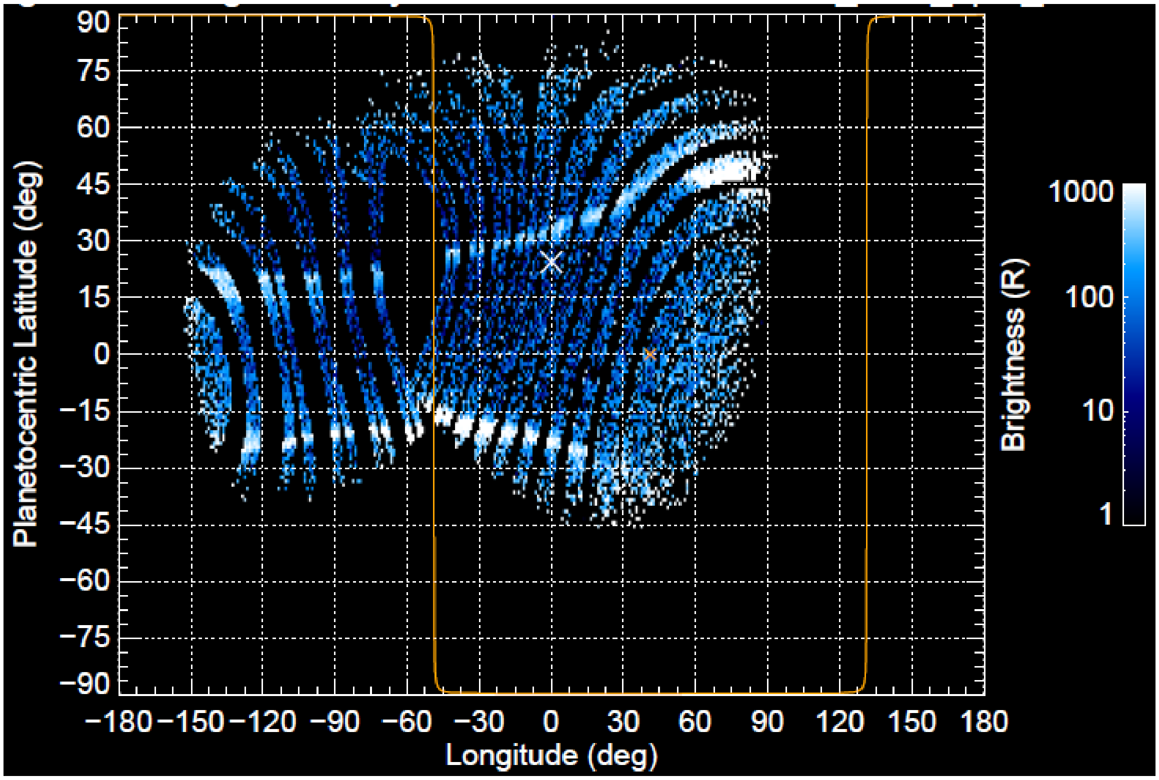


Figure S1. Integrated oxygen emission brightness map observed through the Juno UVS wide slits mapped to the surface of Ganymed at a 1° lat/lon resolution. This figure was produced using the nominal spice kernels and by mapping the emissions to the surface. The subsolar point is shown with the orange x and the terminator is demarcated by the solid orange line, both at the central time of the 30 spin integration of data shown here.

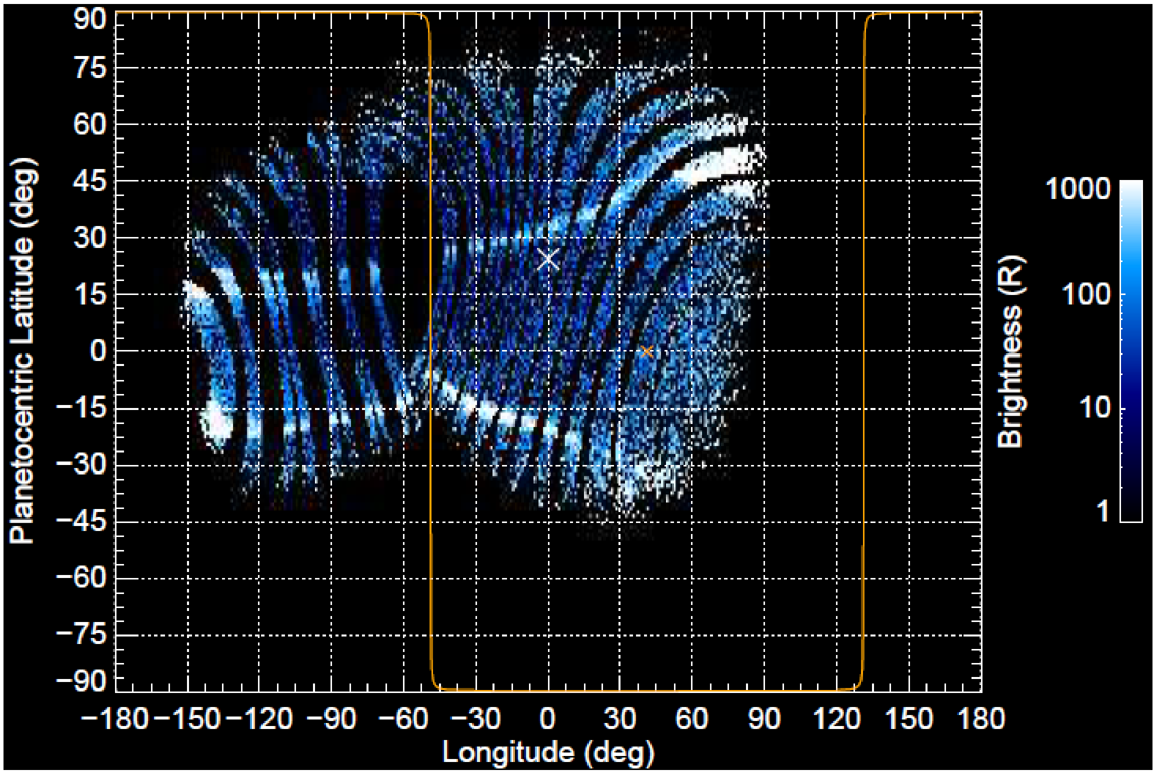
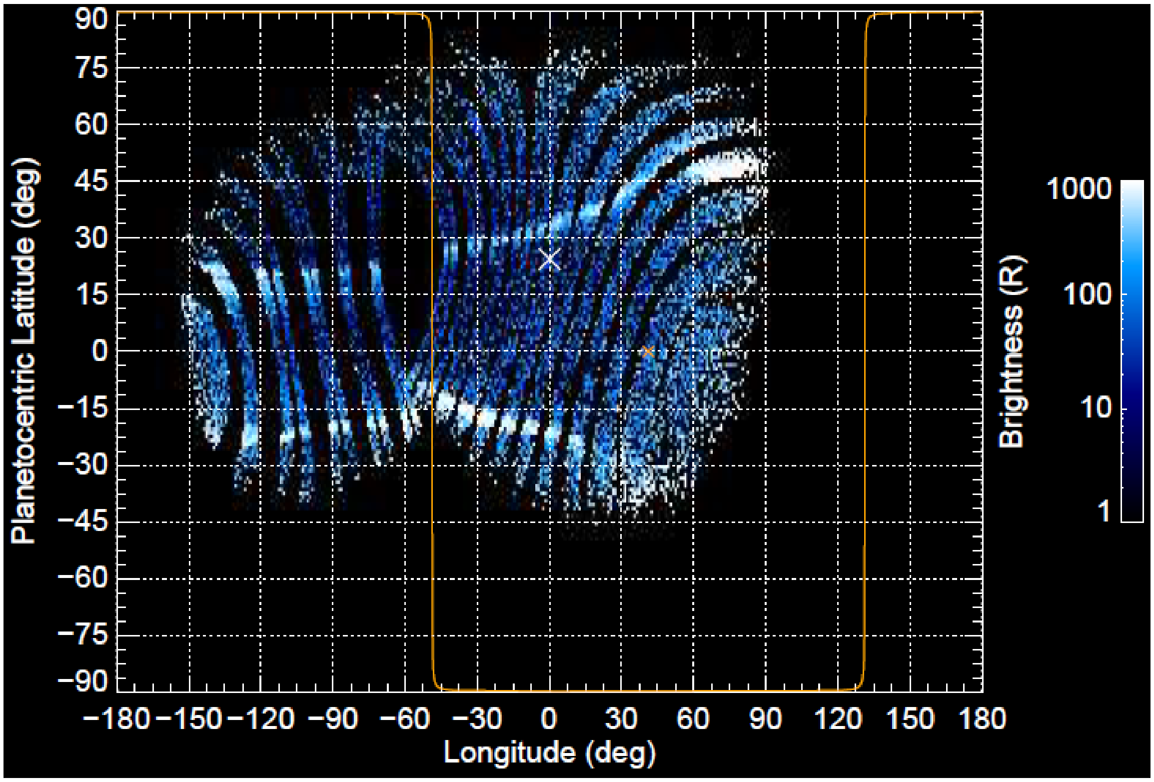
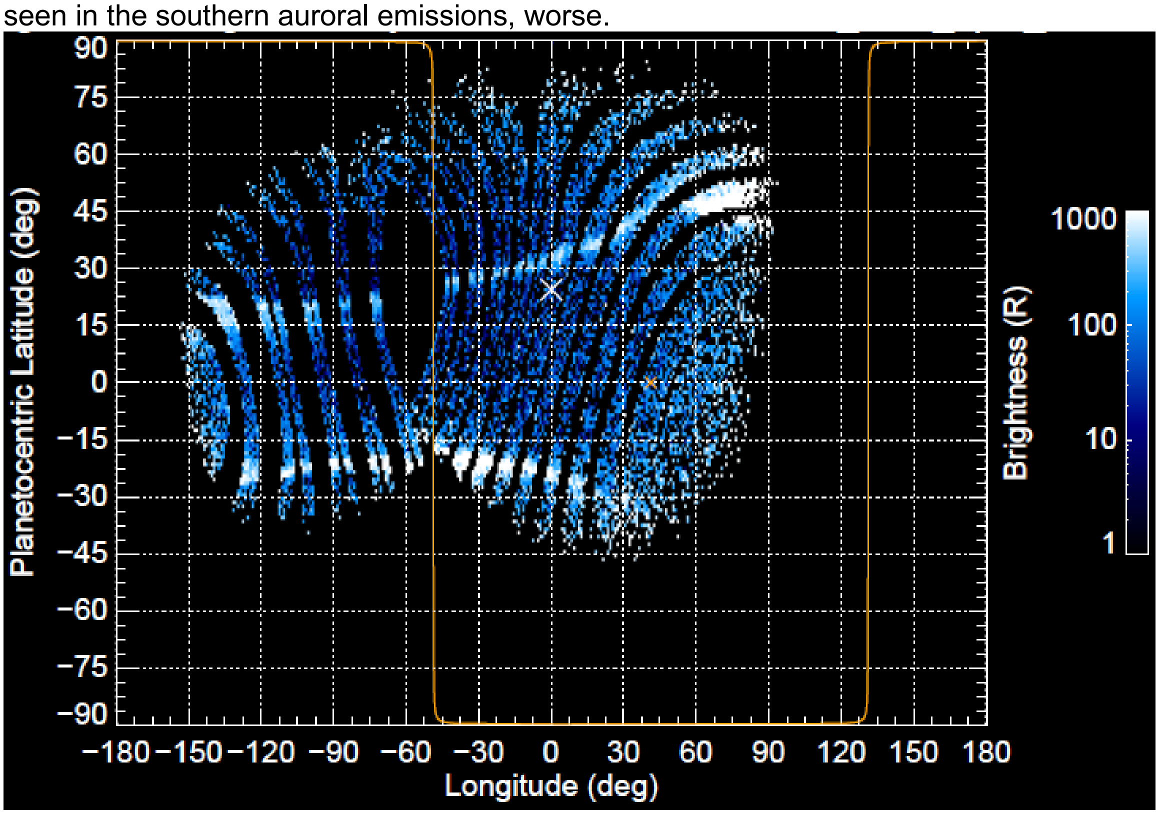


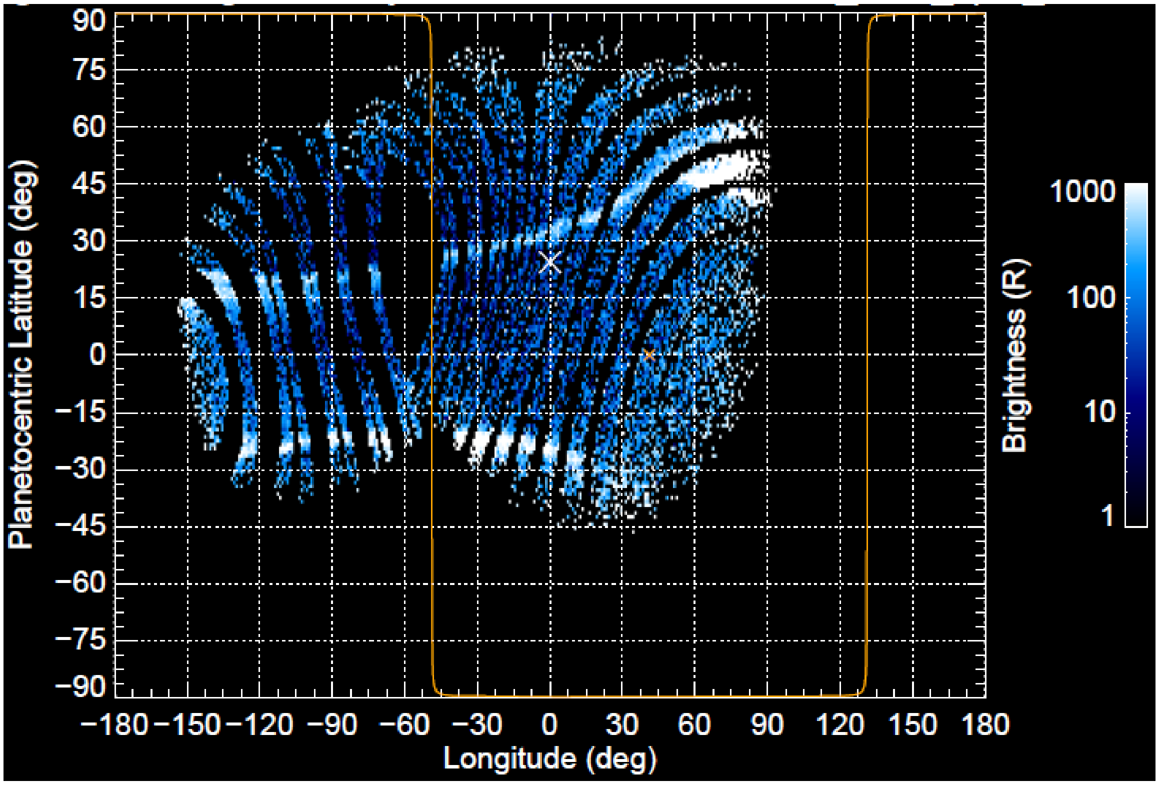
Figure S2. Integrated oxygen emission brightness map observed through the Juno UVS wide slits mapped to 50 km altitude above the Ganymede surface at a 1° lat/lon resolution. This figure was produced using the nominal spice kernels. The subsolar point is shown with the orange x and the terminator is demarcated by the solid orange line, both at the central time of the 30 spin integration of data shown here.



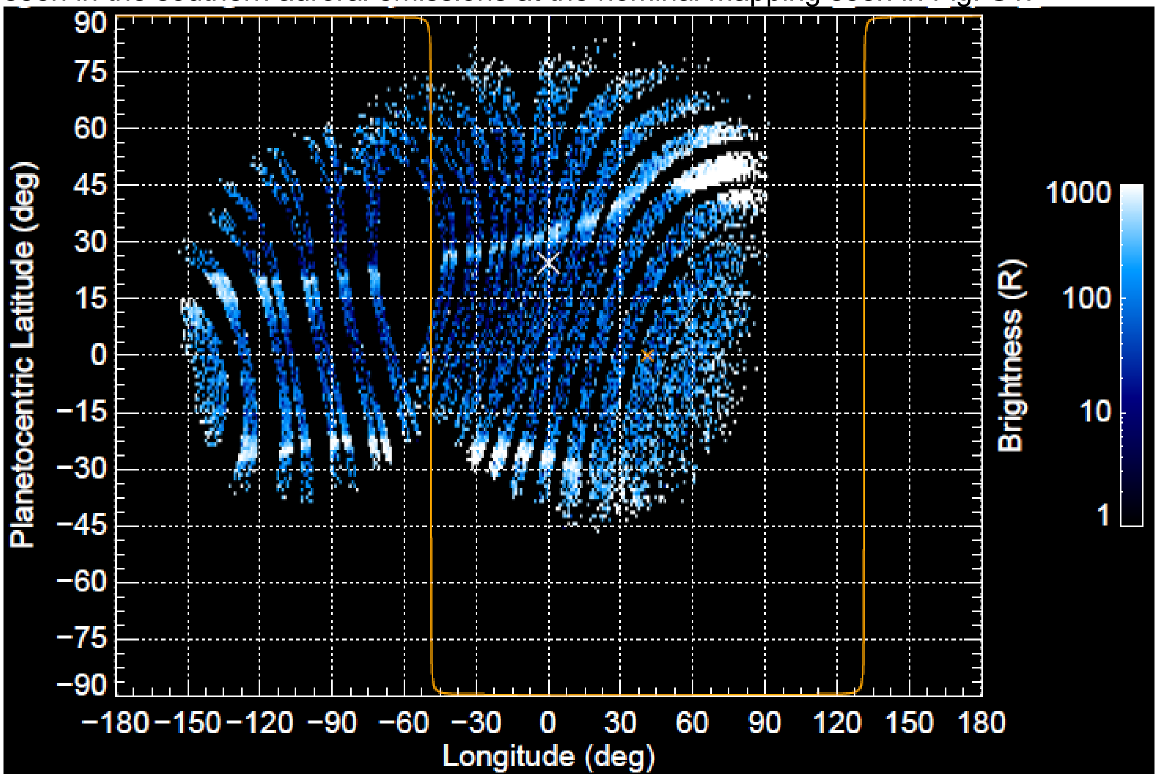
S3) Map of the integrated oxygen emission brightness to the surface of Ganymede with a time offset of +35 ms to the nominal spice mapping (causing a shift in spin phase of the Juno spacecraft relative to Ganymede). This shift appears to make the discontinuity, seen in the southern auroral emissions, worse.



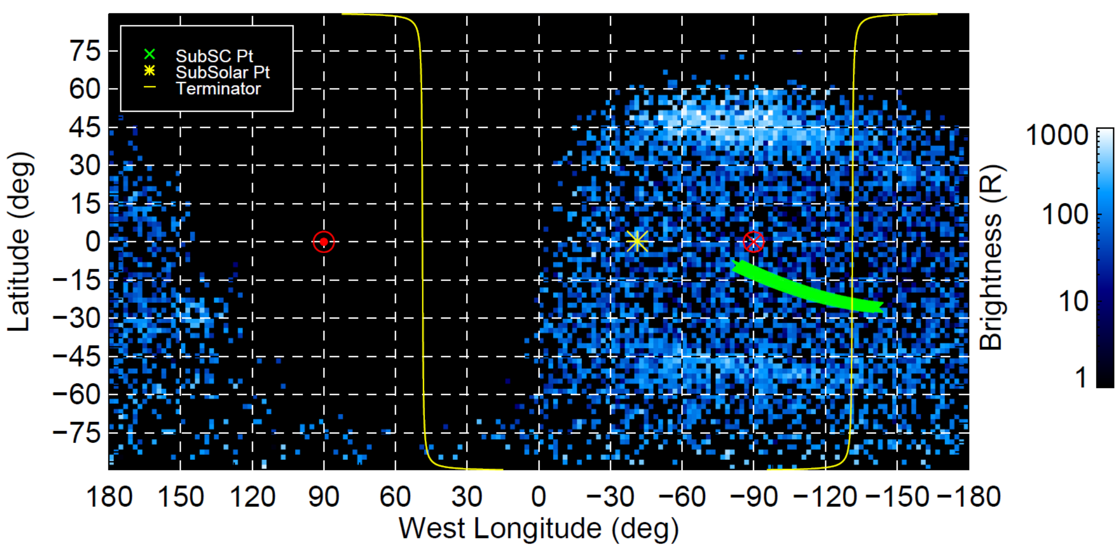
S4) Map of the integrated oxygen emission brightness to the surface of Ganymede with a time offset of -17 ms to the nominal spice mapping (causing a shift in spin phase of the Juno spacecraft relative to Ganymede). This shift appears to reduce the magnitude of the discontinuity, seen in the southern auroral emissions, but not completely correct them.



S5) Map of the integrated oxygen emission brightness to the surface of Ganymede with a time offset of -35 ms to the nominal spice mapping (causing a shift in spin phase of the Juno spacecraft relative to Ganymede). This shift completely removes the discontinuity, seen in the southern auroral emissions at the nominal mapping seen in Fig. S1.



S6) Map of the integrated oxygen emission brightness to the surface of Ganymede with a time offset of -70 ms to the nominal spice mapping (causing a shift in spin phase of the Juno spacecraft relative to Ganymede). This shift completely removes the discontinuity, but begins to make the southern aurora emissions bend south of a nominally straight line where the discontinuity was previously seen. Larger negative temporal shifts makes this effect worse and is obviously not supported by the data or reasonable expectations of the auroral emissions.



S7) Brightness of the integrated 130.4 and 135.6 nm oxygen emissions observed during the Juno PJ35 flyby of Ganymede, binned to a 2°-sampled cylindrical projection, scaled by cos(emission_angle). Green crosses note the sub-spacecraft position at the nadir time of each spin of collected data. The red symbols indicate the plasma flow direction.

References:

Acton, C. H. (1996), Ancillary data services of NASA's Navigation and Ancillary Information Facility, *Planetary and Space Science*, *44*(1), 65-70.