R009-P11
ポスター２：9/25　AM1/AM2 （9:00-12:30）

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Analyzing Brightness of Europa's Auroral Footprint with the HST/STIS Dataset Taken in 2014 and 2022

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Satellite auroral footprints at Jupiter's upper atmosphere are the signature of the electromagnetic interaction between the Galilean moons and the Jovian magnetosphere. Wannawician et al. (2010) revealed that brightness of the Io footprint (IFP) aurora at far-ultraviolet (FUV) wavelength depends on the System III longitudes (λ_{III}) of Io, yet the same variation has not been found at the Europa, Ganymede, and Callisto footprints (EFP, GFP, and CFP, respectively) (e.g., Clark et al., 2002; Bonfond et al., 2013a; Bonfond et al., 2017a, Bhattacharyya et al., 2018). Our study aims to confirm if the brightness of the EFP auroras changes with the System III longitude of Europa as previously found at the IFPs.

Power generated through the moon-plasma interaction depends on the plasma density and magnetic field at the moon and propagates as the Alfven waves along the field lines into Jupiter's ionosphere to accelerate electrons. Hess et al. (2010) estimated the power generated at Io and found that it peaks twice when Io crosses the plasma torus equator at λ_{III} ~110 [deg] (the first peak) and 290 [deg] (the second peak), which corresponds to the peak brightness of the IFP auroras observed at the same longitudes (Wannawichian et al., 2010). This model would also be applicable to the EFPs, but the small number of detected EFP auroras and the low signal-to-noise ratio prevented further discussion of the longitudinal dependence.

We have investigated the variation of the EFP auroral brightness using FUV images taken in 2014 and 2022 by the Space Telescope Imaging Spectrograph (STIS) on the Hubble Space Telescope (HST) with the F25SRF2 filter (130 – 174 nm). In the northern hemisphere, we found that the first peak brightness of the EFP auroras appears when Europa is at λ_{III} ~135 [deg], which is longitudinally shifted from the expected longitude λ_{III} ~110 [deg], although this longitudinal shift is not notable in the IFP auroras according to the analysis by Wannawichian et al. (2010). On the other hand, we have not confirmed the second peak at λ_{III} ~290 [deg] so far, even though the EFP aurora at λ_{III} ~290 [deg] is expected to be brighter than the local minima at λ_{III} ~20 [deg] and 200 [deg] according to the power generation model at Europa as an application of Hess et al. (2010)'s model. The EFP auroras are detected in a range of $82 < \lambda_{III} < 198$ [deg] in the northern hemisphere, although the dataset we use covers wider λ_{III} ranges ($82 < \lambda_{III} < 278$ [deg]) and includes the instantaneous footprints expected by the JRM33 magnetic field model (Connerney et al., 2022) inside the HST's field of view. We have not identified what controls the detectability of the EFP auroras.

As a future work, we will try to reveal (a) why the first peak of the EFP aurora is longitudinally shifted from the model estimation and (b) why the second peak is not detectable in the dataset we use. We expect that comparing satellite footprint auroras of Io, Europa, Ganymede, and Callisto will provide a great opportunity to gain universal understandings of the electromagnetic interaction between the Galilean moons and the Jovian magnetosphere.