Spectroscopic Studies of Europa's Oxygen Atmosphere

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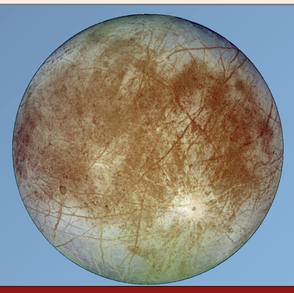
Abstract

Jupiter's moon Europa is one of the most interesting objects in our solar system. Current theory holds that Europa's icy crust covers a liquid water ocean, which may have the ingredients necessary for life. Europa has a tenuous atmosphere, probably created by sputtering of the water ice on its surface by ions from Jupiter's magnetosphere. This atmosphere harbors information about Europa's surface processes, composition, and radiation environment that will be important for future exploratory missions.

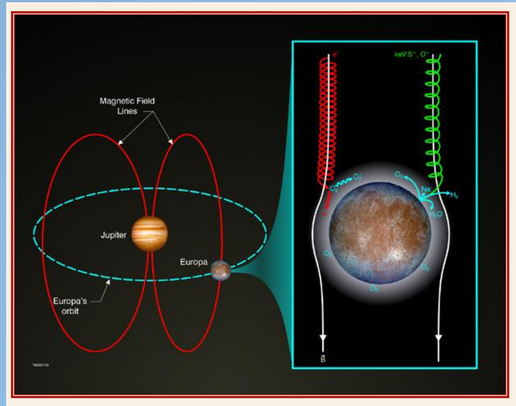
Spectra of Europa taken with the Hubble Space Telescope (HST) reveal a molecular oxygen atmosphere, but apparent variability in the oxygen emission lines has not been fully analyzed. For this project I wrote data reduction programs in IDL to analyze Europa's 1356 Å OI emission line. Our data was taken using the far-UV grating (G140L) of the Goddard High Resolution Spectrograph (GHRS) on HST. Though this data has been added together and measured before, I found that adding fewer spectra together reveals temporal resolution of the variability in the 1356 Å emission line, which is masked by the averaging used in previous papers. This variability has the potential to provide valuable information about Europa's atmosphere.



This background is a false-color image of Europa's surface. The red lines are cracks in the ice, evidence of an active subsurface region.

Europa's Atmosphere

Europa sustains a tenuous oxygen atmosphere, created when ions accelerated through Jupiter's magnetic field slam into the ice on Europa's surface, splitting water molecules into hydrogen and oxygen. This atmosphere has the potential to provide important information about Europa's surface processes and surrounding environment. Scientists are hoping Europa's atmosphere will tell us more about Europa's interior and surface composition.



Europa's atmosphere is created when ions from Jupiter's magnetosphere split ice molecules on Europa's surface in a process called "sputtering."

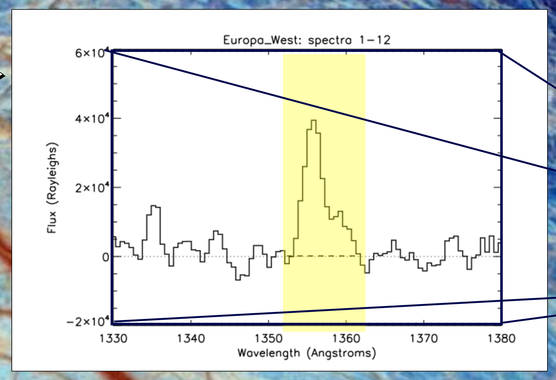
Results

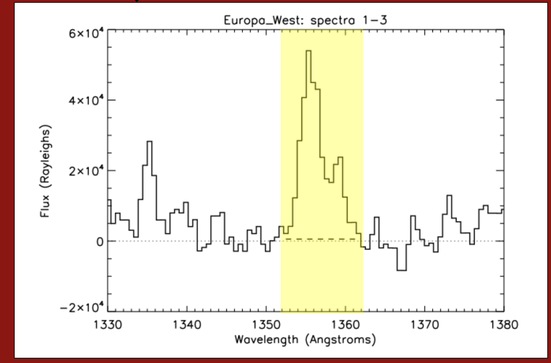
BEFORE

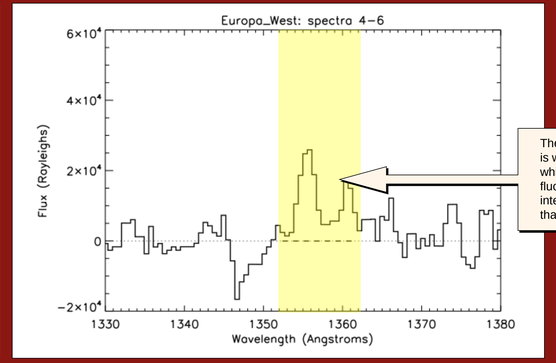
When all of the spectra are added together the signal-to-noise ratio is maximized, but any temporal information is lost.

AFTER

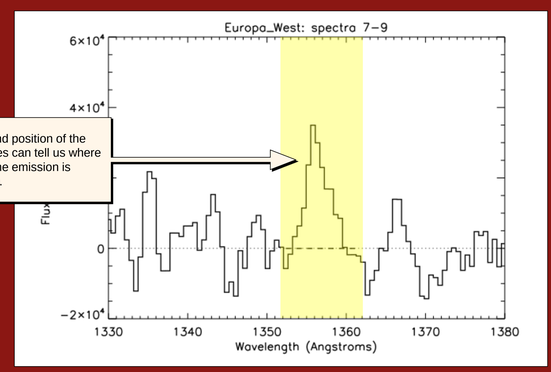
By averaging fewer spectra together, we see that the emission intensity varies significantly over time.



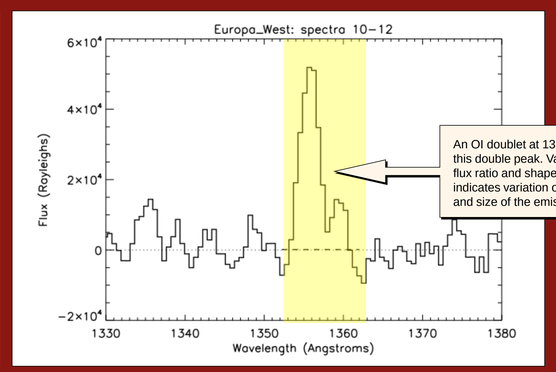




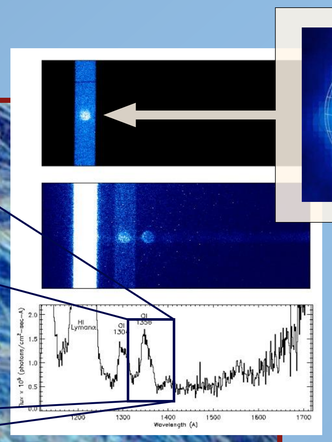
The emission line is weak at times, which indicates fluctuating intensity rather than low signal.



The width and position of the emission lines can tell us where on Europa the emission is coming from.



An OI doublet at 1356 Å creates this double peak. Variation in the flux ratio and shape of this doublet indicates variation of the location and size of the emission region.



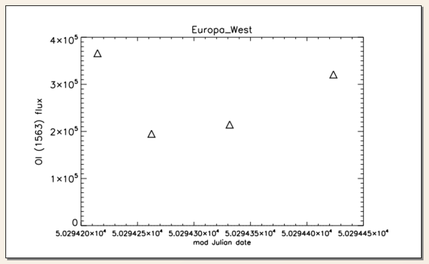
Oxygen emission from Europa's atmosphere as mapped by Hubble at ultraviolet wavelengths (McGrath et al. 2004).

Analysis

This plot shows the change in O_2 flux over time. Though we cannot yet draw any grand conclusions from this variation, the fact that the variation exists indicates that there is much more information to be gleaned from previously published data.

The variability we have uncovered in the oxygen emission of Europa's atmosphere could indicate a number of different things, including:

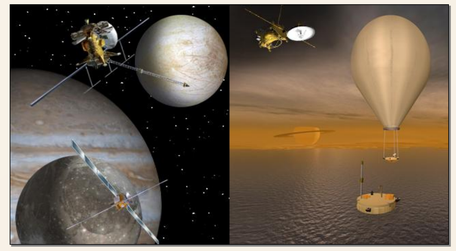
- A non-uniform surface atmosphere (possibly created by plumes).
- Non-uniform surface processes (such as O_2 preferentially sticking to dark surface regions).
- Plasma interaction at the satellite producing a non-uniform illumination of neutrals.



A Mission to Europa

Europa is unique in that it may hold the conditions necessary for life. Beneath its icy crust, Europa may hide an ocean with active vents and plumes, similar to extreme environments found on Earth.

A flagship mission is currently being planned to investigate Jupiter and its satellites, including Europa. It will be important to know about Europa's radiation atmosphere and how it will affect our spacecraft and the instruments onboard. We also need to know what the surface of Europa is like, so that we can design a successful Lander.



An artist's depiction of the next flagship mission to Europa and its ocean.

Conclusion

By limiting the number of spectra added together we decrease the signal-to-noise ratio but uncover temporal resolution that shows the oxygen emission in Europa's atmosphere varying significantly over time. This variability carries information about Europa's atmosphere and surface processes, which will be valuable when designing a spacecraft to investigate Europa.

Future work:

- Extend our data set with previously published data by using the same process of adding fewer spectra together to achieve better temporal resolution.
- Analyze the relationship between O_2 emission and other variables such as System III longitude and magnetic latitude.

Acknowledgments

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