EPSC Abstracts
Vol. 13, EPSC-DPS2019-935-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Rapid Temporal Variability of Condensed Oxygen on Europa?

John R. Spencer (1), William M. Grundy (2), Carl Schmidt (3). (1) Southwest Research Institute, Boulder, Colorado, USA (spencer@boulder.swri.edu) (2) Lowell Observatory, Flagstaff, Arizona, USA (3) Boston University, Boston, USA.

Abstract

New visible-wavelength spectroscopy of Europa provides the best view so far of the enigmatic ~0.3% deep 5770 Å feature due to condensed O_2. The band depth is inconsistent in observations of the same longitude on Europa taken a week apart, which if real implies surprisingly rapid temporal variability. Additional observations are being obtained to further test the reality of these rapid changes.

Introduction

Shallow 5773 Å and 6250 Å absorption bands due to condensed O_2 were detected on the icy Galilean satellites in the 1990s [5, 6]. The band requires high density, condensed, O_2, as it results from interactions between molecules. The band is 2% deep at low latitudes on the trailing side of Ganymede, but much shallower on the poles and leading side, and only 0.3% deep on Europa and Callisto.

The O_2 is probably generated by magnetospheric sputtering of surface H_2O [7], and likely plays a key role in the complex chemical environment of icy satellite surfaces [3, 1] and helps to support the observed O_2 atmosphere [4]. On Europa the O_2 and related oxidants could, when introduced into the ocean by crustal cycling, provide energy to support a potential biosphere [2].

New Observations

The 1990s Europa data, taken with the 1.8-meter Perkins telescope at Lowell Observatory, had insufficient SNR to usefully map longitudinal distribution, an important constraint on formation processes. We have thus obtained new higher SNR spectra using the 4-meter Discovery Channel Telescope (DCT) at Lowell Observatory on 8 partial nights in June 2017, using the DeVeny CCD spectrograph, with $\lambda/\delta\lambda \cong 900$. Europa spectra were divided by contemporaneous Io spectra (which are not expected to contain condensed O_2) to remove solar Fraunhofer lines which otherwise dominate the spectra (Fig. 1).

Results

The new observations provide the highest SNR yet obtained on the 5773 Å O_2 band on Europa and reveal the companion 6250 Å O_2 band for the first time. O_2 band depth is variable (Fig. 1), but is inconsistent in spectra of the same longitude taken a week apart (i.e. June 6^{th} vs. June 13^{th}, and June 5^{th} vs. June 12^{th}). Fig. 2 shows the lack of correlation with longitude more clearly. There is a similar lack of correlation with Europa's Jupiter System III longitude.

Discussion

The apparent rapid temporal variability is surprising, but not easily explained as an artifact. The longitude of Io used in the ratio is the same in the pairs of observations taken 1 week apart, and the same discrepancies are seen when each night's data is separated into two halves (Fig. 2), though uncertainties do not always overlap, which is a concern. *If real*, the variability might be due to O_2 deposition by short-lived plumes, and subsequent sublimation, or variability of production by magnetospheric sputtering. Further observations will be obtained with DCT in June 2019 in the hope of confirming or refuting this peculiar result.

Acknowledgements

This work was funded by NASA Solar System Observations grant NNX16AG63G

References

[1] Carlson, R. et al.: Hydrogen Peroxide on the surface of Europa., Science 283, 2062, 1999.

[2] Hand, K. et al: Astrobiology and the potential for life on Europa, in *Europa*, Pappalardo, R. et al., eds., U.A. Press, p.589, 2009.

[3] McCord, T. et al.: Non-water-ice constituents in the surface material of the icy Galilean satellites from the Galileo near-infrared mapping spectrometer investigation, J. Geophys. Res 103, 8603, 1988.

[4] Roth L. et al.: Europa's far ultraviolet oxygen aurora from a comprehensive set of HST observations, J. Geophys. Res. 121, 2143, 2016.

[5] Spencer, J., Calvin, W., Person, M.: CCD spectra of the Galilean satellites: Molecular oxygen on Ganymede, J. Geophys. Res. 100, 19049, 1995.

[6] Spencer, J. and Calvin, W.: Condensed O_2 on Europa and Callisto, Astron. J. 124, 3400, 2002.

[7] Teolis, B., Plainaki, C.; Cassidy, T. A.; Raut, U.: Water Ice radiolytic O_2, H_2, and H_2O_2 yields for any projectile species, energy, or temperature: A model for icy astrophysical bodies, J. Geophys. Res. 122, 1996, 2017.

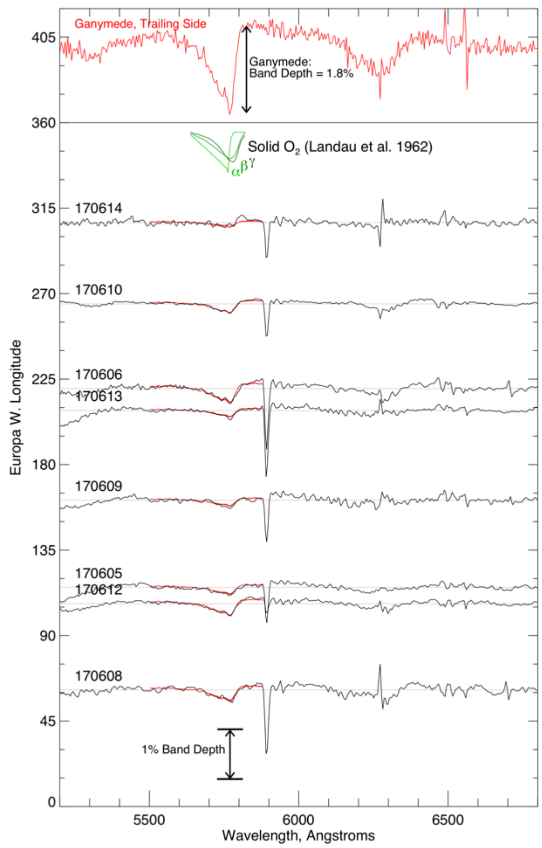

Figure 1. Europa/Io spectral ratios, arranged by longitude, from our 2017 DCT run. Red curves show fits to a scaled Ganymede spectrum (top), used to determine band depth. The feature at 5890 Å is Na emission on Io.

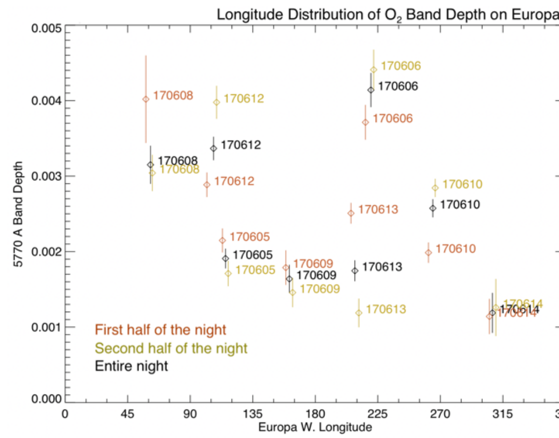

Figure 2. Band depth vs. longitude, showing the lack of correlation. Depths are shown for the full night, and also for the first and second halves of each night.