DETECTION OF A HYDROGEN CORONA AT CALLISTO IN HST/STIS LYMAN-α IMAGES.
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Introduction: In December 2001, far-ultraviolet spectral images of Jupiter's moon Callisto were obtained by the Space Telescope Imaging Spectrograph (STIS) of the Hubble Space Telescope (HST) in the search for carbon and oxygen atmospheric emissions. On two occasions, the leading and trailing hemispheres were observed with the moon at eastern and western elongations, respectively. No measurable oxygen or carbon emissions were detected [1]. We re-analyzed the hydrogen Lyman-α (1216 Å) images in these 2001 STIS observations in the search for emissions from hydrogen-bearing atmospheric constituents.

Observations and Method: During two visits on 2001 December 15 and 24, the images were obtained with HST/STIS using the G140L grating and the 52"x2" slit covering wavelengths between 1120 Å and 1720 Å. The two visits were scheduled only half an orbital period of Callisto apart to observe Callisto's trailing and leading hemispheres in the same orbit. During each visit ten exposures were taken over a period of ~7 hours or five HST orbits. With an angular diameter of ~1.6", Callisto’s disk is entirely imaged within the 2" slit, with a spatial resolution of ~75 km/pixel or ~64 pixels across the moon.

To improve the signal-to-noise ratio, we add all ten exposures of each visit together. The change in viewing geometry or sub-observer longitude over the visits is <6º and thus minimal. The strongest signal is detected at Lyman-α, where emissions from the Earth’s geocorona and the interplanetary (IPM) media fill the entire slit. In addition, the trace of solar flux reflected off Callisto’s surface near the center of the detector along the horizontal dispersion axis.

Our analysis focuses on the Lyman-α emission in the slit centered on 1216 Å. Due to slight misalignment of the slit orientation and the detector axis, we avoid the regions near the edges of the slit and take into account only the region of 64 pixels around the slit center.

The strongest contribution to the signal with more than ~6 kiloRayleigh (kR) originates from the slit-filling geocorona and IPM emissions. Surface-reflected sunlight contributes another 1-2 kR to the signal on the disk of Callisto. A comparably faint signal of a few hundred Rayleighs is detected above the limb of Callisto, which can be attributed to resonantly scattered light from an atomic hydrogen corona. Because the STIS point-spread-function (PSF) also scatters surface-reflected sunlight to regions above the limb, we develop a forward model that takes into account all three contributions to the Lyman-α signal as well as the PSF effects. Simultaneously fitting parameters for Callisto’s surface reflectance (or albedo) and the H abundance, we derive constraints for the corona.

Results: We find that faint atmospheric Lyman-α emissions extending up to several moon radii away are present in addition to the solar Lyman-α flux reflected off the surface. We show that the detected atmospheric Lyman-α emissions are consistent with an escaping hydrogen exosphere with a vertical column density in the range of $(3 – 9) \times 10^{11}$ H/cm^2. The derived hydrogen abundance is approximately two times higher at eastern elongation, possibly related to increased water sublimation when the visibly darker leading hemisphere is illuminated by the sun [2].

References:

[1] Strobel, D.F., J.Saur, P.D. Feldman, and M. A. McGrath (2002). Hubble Space Telescope space telescope imaging spectrograph search for an atmosphere on Callisto: A jovian unipolar inductor. *Astrophys. J. 581, L51–L54.*

[2] Moore, Jeffrey M., et al. "Callisto." *Jupiter. The Planet, Satellites and Magnetosphere* 1 (2004): 397-426.