The Astrophysical Journal Letters, 966:L40 (3pp), 2024 May 10 https://doi.org/10.3847/2041-8213/ad4497

Erratum: "Large Volcanic Event on Io Inferred from Jovian Sodium Nebula Brightening" (2019, ApJL, 871, L23)

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Received 2024 April 24; published 2024 May 9

In 2019, an instrument change to the Io Input/Output observatory (IoIO) coronagraph increased the distance between the neutral density (ND) filter and filter wheel and led to the unexpected discovery that the light of Jupiter passing through the ND filter cannot be used as a reliable photometric calibration source. We suspect that multiple reflections between the bottom side of the highly reflective ND filter and top side of whatever filter is positioned underneath it are responsible for the issue. These multiple reflections reduce the effective transmission of the system such that sources imaged through the ND filter appear brighter than one would expect by multiplying the individually measured transmissions of the optical elements. The magnitude of the effect is different for each filter listed in Table 1 of the published article because the efficiency of the antireflective coating of each filter is different. For instance, the effect may be as small as 1.2 for the *R*-band filter and as large as a factor of 10 for the narrowband filters. Regardless of the physical cause, data recorded before and after the instrument change showed significant changes in the factors ADU2R, OFFSCALE, and the time-variable factor of 0.8 attributed to off-axis scattered light in the Na on-band filter, making it clear that the entire premise of using light from Jupiter to aid photometric reduction and calibration of the IoIO data set was fundamentally flawed.

To derive the corrected Na nebula surface-brightness values, shown in Figure 1, we used a multiyear set of Burnashev (1985) spectrophotometric star observations and day-sky flats. Stellar observations were recorded with the stars offset from the ND filter, thus avoiding any issues with the interaction between the ND and narrowband filters. Similar standard star observations were used to calibrate coronagraphic observation of the Na nebula (Mendillo et al. 1990, 2004; Yoneda et al. 2009, 2010, 2015; Roth et al. 2020) and spectrographic observations of the Io plasma torus (IPT; Thomas 1993; Thomas et al. 2001). Our new calibration data and details of the improved Na nebula reduction and calibration procedures are discussed by Morgenthaler et al. (2024), who extend the time coverage of the Na nebula data set through 2023 and present contemporaneous observations of the IPT in [S II] 6731 Å.

We find that the Na nebula surface-brightness values presented in our original work were high by a factor of ∼10. The general character of the high surface-brightness features in the corrected Na nebula images is unchanged, but there are subtle long-term time-dependent differences in the lower surface-brightness regions due to the erroneous methodology we used to scale the Na off-band images before they were subtracted from the Na on-band images. The corrected surface-brightness values therefore show that an enhancement in the Na nebula is still seen in 2018 but peaks 2028 May, rather than two months earlier, as suggested in the published article. The onset of the enhancement is in late February, rather than early January.

Importantly, light from Jupiter see through instrument ND filters has frequently been used to calibrate coronagraphic observations of diffuse gas around Jupiter and Io, both in imaging and spectrographic instrumentation (e.g., Schneider et al. 1991; Brown 1994a, 1994b; Wilson & Schneider 1994; Brown 1995; Schneider & Trauger 1995; Brown & Bouchez 1997; Woodward et al. 1999, 2000; Schmidt et al. 2018; Kagitani et al. 2020). We have reviewed available information on the instrument setups and calibration procedures used in these observations and found that only the spectroscopic observations of the Na nebula and IPT recorded at the Lick Observatory in 1991 (Brown 1994a, 1994b, 1995; Brown & Bouchez 1997) may be subject to a similar multiple-reflection effect that could make photometric calibration suspect. This is because of two instrumentation changes made for the observations: (1) an ND filter was inserted at the focal plane of the telescope, and (2) a narrowband order-separating filter was used to put the Hamilton Echelle Spectrograph into long-slit mode. Although orientation of these filters relative to the optical axis of the spectrograph or each other was not recorded, difficulty in calibrating the opacity of the ND filter was (Brown 1994a). Most of the rest of the coronagraphic observations were conducted by instruments in which the ND filter was tilted relative to the optical path to enable guiding from front-surface reflection. In the case of the Dual Imaging Spectrograph torus measurements, the ND filter opacity was measured using continuum light from Jupiter in an end-to-end test at the same wavelengths and instrument configuration as the science observations; thus these observations are likely to be well calibrated (Schmidt et al. 2018). Finally, the novel coronagraphic technique developed by Kagitani et al. (2020) uses a micromirror array to function as an adaptive occultation mask. Light from Jupiter (or other bright objects) is directed along a different path than the light to be studied for science purposes. Thus, this technique is immune to the multiple-reflection effect.

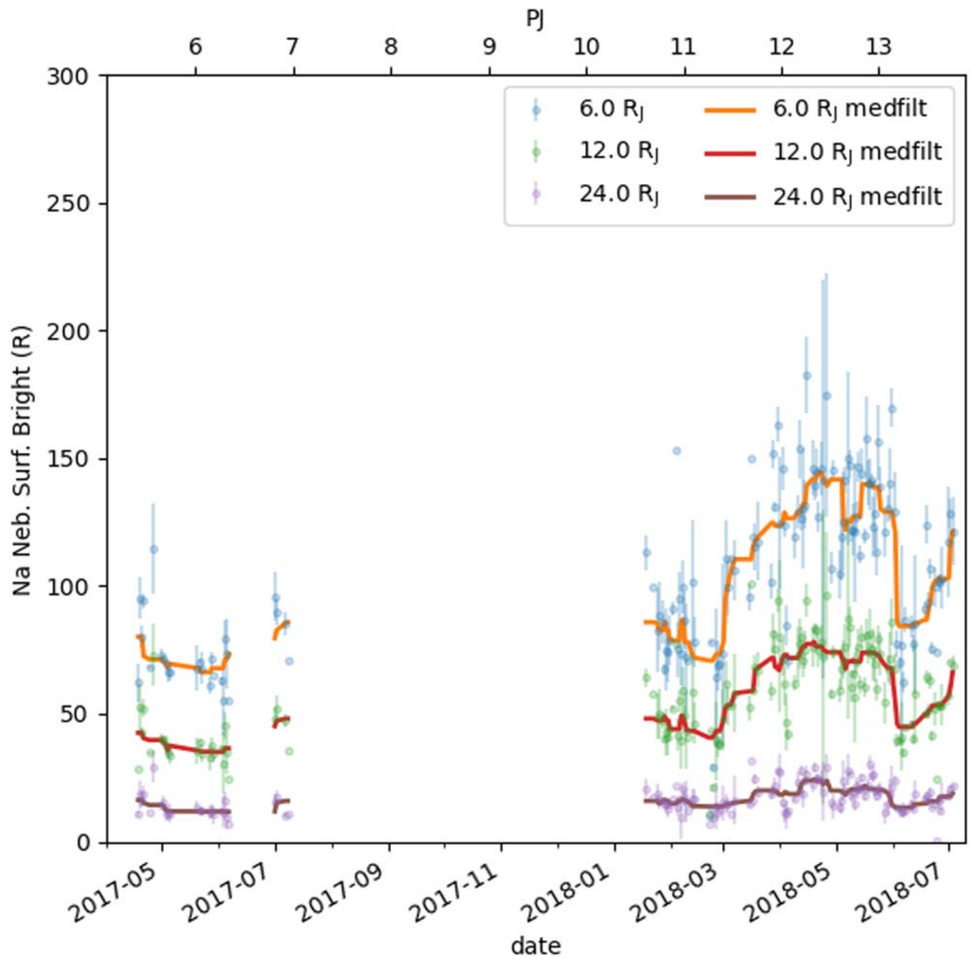

Figure 1. Revised time sequence of the surface brightness of the Jovian sodium nebula for the three Jovicentric distances above and below the torus centrifugal plane. A 21-point median filter threads through the points. For the data behind the figure and the code to read it, see Morgenthaler et al. (2023) and Morgenthaler (2023). The revised observation and reduction methodology are described in Morgenthaler et al. (2024).

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