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TITLE: Discovery of three fullerene-containing young planetary nebulae

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ABSTRACT:

To understand and investigate the properties of fullerene-containing young planetary nebulae (YPNe), we study a small sample of three YPNe (BI 2-1, K 3-60, and M 4-18) mainly through Hubble Space Telescope (HST) imaging observations and Spitzer infrared (IR) spectroscopic measurements. The neutral C₆₀ and C₇₀ features are identified in the IR spectra of these YPNe for the first time. Comparing to normal C-rich young nebulae, the fullerene-containing YPNe show lower C/O abundance ratios and differential excited state distributions. In addition to neutral fullerene bands, other unidentified infrared emissions (UIEs) such as 16.4 μm features are found in all these compact YPNe. We report that IR bands of highly positively charged fullerenes like C₆₀¹⁴⁺ can assign to these UIEs within the same error range as for neutral fullerenes. Considering the estimated temperatures of the center stars of these objects. Because of this direct link of physical condition and fullerenes astrochemistry, we also studied the morphology of these objects in detail. The high angular-resolution HST images clearly reveal that the nebula of BI 2-1 has a well-defined elliptical appearance and another two YPNe (K 3-60 and M 4-18) exhibit a bipolar structure. Further analysis of the spectral energy distribution for M 4-18 suggests a binary central source in this YPN, which may further support the link between the fullerene formation and its central binary.