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NuSTAR and Swift Observations of the Ultraluminous X-Ray Source IC 342 X-1 in 2016: Witnessing Spectral Evolution

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Abstract

© 2017. The American Astronomical Society. All rights reserved. We report on an X-ray observing campaign of the ultraluminous X-ray source IC 342 X-1 with NuSTAR and Swift in 2016 October, in which we captured the very moment when the source showed spectral variation. The Swift/XRT spectrum obtained in October 9-11 has a power-law shape and is consistent with those observed in the coordinated XMM-Newton and NuSTAR observations in 2012. In October 16-17, when the 3-10 keV flux became ≈4 times higher, we performed simultaneous NuSTAR and Swift observations. In this epoch, the source showed a more round-shaped spectrum like that seen with ASCA23 years ago. Thanks to the wide energy coverage and high sensitivity of NuSTAR, we obtained hard X-ray data covering up to ~30 keV for the first time during the high-luminosity state of IC 342 X-1. The observed spectrum has a broader profile than the multi-color disk blackbody model. The X-ray flux decreased again in the last several hours of the NuSTAR observation, when the spectral shape approached those seen in 2012 and 2016 October 9-11. The spectra obtained in our observations and in 2012 can be commonly described with disk emission and its Comptonization in cool ($T_e \approx 4$ keV), optically thick ($\tau \approx 5$) plasma. The spectral turnover seen at around 5-10 keV shifts to higher energies as the X-ray luminosity decreases. This behavior is consistent with that predicted from recent numerical simulations of super-Eddington accretion flows with Compton-thick outflows. We suggest that the spectral evolution observed in IC 342 X-1 can be explained by a smooth change in mass-accretion rate.

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Keywords

accretion, accretion disks, black hole physics, X-rays: binaries, X-rays: individual (IC 342 X-1)

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