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Multiwavelength Properties of the Newly Discovered Dwarf Nova ASASSN-21kt

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Abstract

We report on archival XMM-Newton and post-outburst Swift observations of the newly discovered dwarf nova ASASSN-21kt. Its pre-outburst X-ray emission is consistent with that of a collisionally ionized, thermal plasma with $kT = 8.1^{+10.2}_{-2.5}$ keV and $L_{X0.2-12\text{ keV}} = 7 \times 10^{32}$ erg s⁻¹, with no clear modulation. Multiple optical outbursts revealed by Gaia and time evolution of the last one followed by the All-Sky Automated Survey for Supernovae, and X-ray properties presented here support the dwarf nova classification of ASASSN-21kt.

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1. Introduction

The optical transient ASASSN-21kt (Gaia21cxy, AT 2021puv) was discovered on 2021 June 13.19 UT (Stanek [2021](#)) by the All-Sky Automated Survey for Supernovae (ASAS-SN; Shappee et al. [2014](#); Kochanek et al. [2017](#)) at $g = 14.67 \pm 0.03$ (Stanek [2021](#)). The object brightened in ~ 2 days and faded over the subsequent ~ 9 days. It was independently detected (R.A. = 14:08:10.55; decl. = $-45:26:50.7$, J2000) by the star-mapping satellite Gaia at $G = 15.83$ on 2021 June 18.94 and announced as Gaia21cxy [10](#) through the Gaia Science Alerts (GSA; Hodgkin et al. [2021](#)). The Gaia lightcurve reveals three unannounced previous outbursts since 2014 August 30—on 2016 September 1, 2017 July 20, and 2019 December 19, with peak magnitudes of 15.65, 15.61, and 15.51, respectively. The quiescent G magnitudes are between 19.19 and 20.56. The GSA triggered our program of characterizing cataclysmic variable candidates with archival XMM-Newton observations. The recurrent outbursts seen by Gaia together with fast-rising/slowly fading shape of the outburst seen by ASAS-SN suggest the source to be a dwarf nova (DN; e.g., Hellier [2001](#); Warner [2003](#)). Here we report on its X-ray properties from XMM-Newton observations and UV photometry from the Neil Gehrels Swift Observatory.

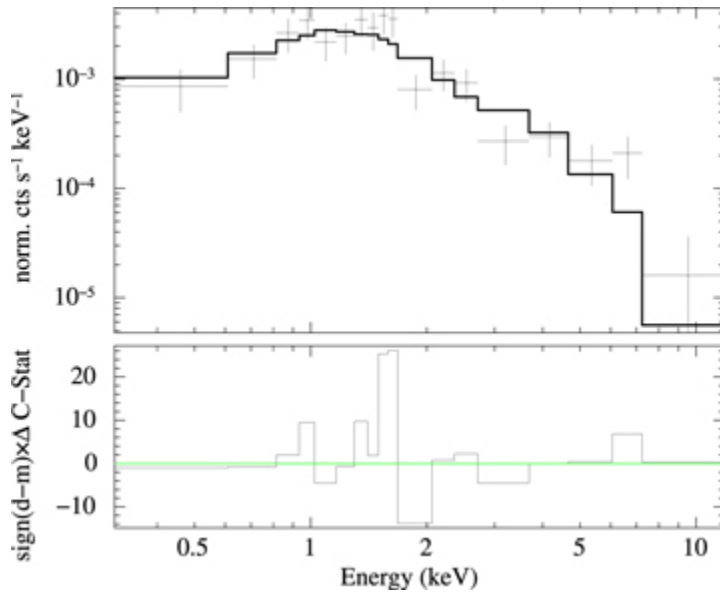
2. Observations

The Gaia coordinates of ASASSN-21kt are consistent within $0''.9$ with those of the X-ray source 4XMM J140810.6-452650 [11](#) (with position accurate to $\sim 1''.4$) listed in the XMM-Newton Serendipitous Source Catalog (4XMM-DR10; Webb et al. [2020](#)). The source was serendipitously observed in extreme off-axis positions on the three XMM-Newton pointings (all centered on the object V834 Cen) carried out on 2002 February 19 (ObsID 0109462401; in the field of view (FoV) of the MOS1 and MOS2 cameras, whose good time intervals—GTI—with low background totaled ~ 3.1 ks and ~ 5.6 ks, respectively, while pn was turned off), on 2002 July 31 (ObsID 0109463801; barely detected by MOS2, with GTI ~ 6 ks, but not in the FoV of the MOS1 and pn cameras), and on 2007 January 30 (ObsID 0405520301; well detected for MOS2, with GTI ~ 31.7 ks, and out for MOS1 and pn). The data reduction followed standard procedures with the `Science Analysis Software v19.1.0` and spectral investigation with `Xspec/v12.11.1` (Arnaud [1996](#)). The 2007 spectrum was constructed such that each energy bin has at least 1 count and modeled with the C -stat-fit and the χ^2 -test statistics. We searched for periodicities from photon arrival times with the Z2n periodogram (Buccheri et al. [1983](#)). We also report on X-ray (XRT) and UV (UVOT) Swift observations of ASASSN-21kt, which were conducted just after the 2021 outburst in a 2.6 ks campaign on 2021 June 27/30.

3. Results and Discussion

Only the 2007 XMM-Newton observation accumulated enough counts to allow spectral and some timing investigation. There is no statistically significant modulation with

period in the range from 10 s to 21.3 ks at 0.5–5 keV. Although the spectrum did not allow to constrain the cooling flow model expected to represent most of the X-ray emission of accreting white dwarfs (Mukai [2017](#)), it revealed ASASSN-21kt to be at least a mild hard X-ray emitter. Figure 1 shows the MOS2 spectrum, rebinned for a better visualization. The emission is consistent ($\chi^2/\text{dof} = 146/166$) with a hot-thermal plasma (APEC in `xspec`) having $kT = 8.1^{+10.2}_{-2.5}$ keV (at 1σ) and solar abundance (following the abundance table of Asplund et al. [2009](#)), suffering photoelectric absorption (PHABS in `xspec`) equivalent to a Hydrogen column of $N_H = 1.4^{+0.7}_{-0.6} \times 10^{21} \text{ cm}^{-2}$. The unabsorbed (0.2–12 keV) flux is $\sim 3.9 \times 10^{-13} \text{ erg cm}^{-2} \text{ s}^{-1}$, corresponding to $L_X \sim 7 \times 10^{32} \text{ erg s}^{-1}$ at $d_{\text{Gaia}} = 3.8^{+2.4}_{-1.6} \text{ kpc}$ (Bailer-Jones et al. [2021](#)). A close inspection of the original binned spectrum suggests the presence of Fe $K\alpha$ complex in emission, supporting the dominant thermal nature of the emission as expected for accreting white dwarfs.



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Figure 1. X-ray spectrum and residuals.

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From the MOS2 data, the background corrected count rate of ASASSN-21kt at 0.3–12 keV was $0.006 \pm 0.003 \text{ counts s}^{-1}$ on 2002 February 19, $0.0024 \pm 0.0008 \text{ counts s}^{-1}$ on 2002 July 31, and $0.0052 \pm 0.0004 \text{ counts s}^{-1}$ on 2007 January 30. Assuming the latter condition and the best fit parameters derived here, WebPIMMs [12](#) predicts $0.0013 \text{ counts s}^{-1}$ with Swift/XRT in photon counting mode.

Swift/XRT observations in photon counting mode carried out ~ 15 days after the 2021 outburst detected no X-ray source at the position of the transient with a 1σ upper limit of $0.004 \text{ counts s}^{-1}$. For the kT and N_H values derived from the XMM-Newton observation,

the Swift/XRT upper limit is $2.5 \times 10^{-13} \text{ erg cm}^{-2} \text{ s}^{-1}$ ($L_X < 4 \times 10^{32} \text{ erg s}^{-1}$). ASASSN-21kt was within the FoV of Swift/XRT in the 2.0 ks observation of V834 Cen conducted on 2019 June 2 during optical quiescence, but was not detected with an upper limit comparable to the post-outburst observation. The Swift/XRT non-detections are expected if the source flux remained as it was during the XMM-Newton observation.

An ultraviolet source is detected in post-outburst observations by Swift/UVOT at the position of ASASSN-21kt with the following magnitudes (Vega system): $U = 18.76 \pm 0.14$ (JD 2459392.71), $UVW2 = 18.96 \pm 0.15$ (JD 2459394.07), and $UVW1 = 19.04 \pm 0.11$ (JD 2459396.10). According to the ASAS-SN photometry, the transient dimmed below the detection limit of $g \sim 16$ by the time of Swift observations. The source was not in the FoV of the Optical Monitor camera onboard XMM-Newton in the archival observations and in the pre-outburst Swift/UVOT observation.

We estimate the V -band extinction A_V assuming that the absorption seen in X-rays is due to Galactic/ISM absorbers and using the relation (Güver & Özel 2009):

$$A_V = 0.452 \times 10^{-21} N_H = 0.63. \quad (1)$$

For white stars ($V - Ic = 0$ and low extinction (< 1 mag), the extinction in Gaia's band is $A_G = 0.95 A_V = 0.6$ (Table 8 of Jordi et al. 2010). Thus M_G is $\sim +2.3$ during the 2021 outburst, which is consistent with the DN interpretation, but only if ASASSN-21kt has a relatively long (≥ 8 hr) orbital period for a DN so that a large accretion disk may be accommodated (Patterson 2011). The L_X is also high for a DN, which is typically $< 10^{32} \text{ erg s}^{-1}$ (Byckling et al. 2010), but there are long orbital period DN known to have similarly high L_X (e.g., BV Cen at $3.5 \times 10^{32} \text{ erg s}^{-1}$; Wada et al. 2017).

4. Conclusions

The recurrent optical outbursts of ASASSN-21kt are consistent with those expected for a cataclysmic variable, DN system, as previously noted (see, e.g., <http://gsaweb.ast.cam.ac.uk/alerts/alert/Gaia21cxy/>). We show here that its X-ray emission, including the lack (so far) of periodic modulation are consistent with that interpretation. We encourage optical spectroscopy and a dedicated X-ray campaign to better constraining its physical properties.

This research has made use of the 4XMM/XMM-Newton/ESA catalog. We acknowledge the use of public data from the Swift data archive, ESA/Gaia, DPAC and the Photometric Science Alerts Team (<http://gsaweb.ast.cam.ac.uk/alerts>). R.L.O. acknowledges financial support from the Brazilian institutions CNPq (PQ-312705/2020-4) and FAPESP (#2020/00457-4). K.S. was supported by NASA grants NASA/NuSTAR 80NSSC21K0277, NASA/Fermi 80NSSC20K1535, and NASA/Swift 80NSSC21K0173, from a Cottrell Scholarship from the Research Corporation and the Packard Foundation.

Facilities: XMM - Newton X-Ray Multimirror Mission satellite, Swift - , Gaia. -

Footnotes

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The ASAS-SN magnitudes of ASASSN-21kt might be contaminated by "nearby" stars.

• 9

<https://asas-sn.osu.edu>

• 10

<http://gsaweb.ast.cam.ac.uk/alerts/alert/Gaia21cxy/>

• 11

<http://xmm-catalog.irap.omp.eu/source/201094638010006>

• 12

<https://heasarc.gsfc.nasa.gov/cgi-bin/Tools/w3pimms/w3pimms.pl>

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