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Candidate Radio Counterparts to the 2021 Nov. X-ray binary outburst in NGC 6440

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We report preliminary results from VLA radio observations of the globular cluster NGC 6440, which recently showed transient X-ray activity from a neutron star X-ray binary (ATel #15033, #15048). We took B config VLA observations on 2021 Nov 24 at 20:19:54-22:43:33 UTC (MJD = 59542.8472-59542.9469), in X-band (8-12 GHz).

We conservatively search a 135" radius centred on the NuSTAR X-ray detection from this outburst (with its 45" error), and detect a radio source 75" from the NuSTAR position. We fit a 2-D Gaussian to this detection, finding a peak flux density of 12.0+/-2.3 muJy with a 1.9+/-0.5" by 0.70+/-0.08â ellipse (major and minor axes) at PA = 14+/-4 deg. This is marginally extended compared to the synthesized beam of 1.3" by 0.75" at PA = 6 deg. We estimate VLA astrometric errors as the larger of the beam/(2*SNR) and a systematic-error limited 1/10th times the Gaussian shape. The source position is RA=17:48:54.139 and Dec=-20:20:44.42 (all positions reported are FK5 J2000) with errors of 0.09" and 0.18", respectively. Fixing the Gaussian to the shape of the beam, the source flux density increases to 13.6 muJy and the position is RA=17:48:54.136 and Dec=-20:20:44.53 with errors of 0.08" and 0.13", respectively. We preliminarily name this source VLA J174854.1-202044. Archival C-band 4-8 GHz VLA images from the MAVERIC project (Shishkovsky et al. 2020, ApJ, 903 ,73) indicate no radio source, with a stacked 3-sigma upper limit of 5.8 muJy. Thus, VLA J174854.1-202044 is likely to be a transient radio source, but we cannot definitely label it as such.

We detect no X-ray source in archival Chandra data for NGC 6440 (ObsIDs 10060, 947,

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3799; 96 ks combined) at the location of VLA J174854.1-202044. From 2 photons (0.3-7 keV) within 1", we estimate a 3-sigma upper limit on the quiescent 1-10 keV X-ray luminosity of 2.1e31 erg/s for a Gamma=2.1 power-law absorbed by 1.0e22 cm^-2 (Bahramian et al. 2015, MNRAS, 452, 3475). This luminosity is consistent with fainter quiescent X-ray binaries. VLA J174854.1-202044 is marginally consistent with a faint optical source in archival HST WFC3 observations (F814W=23.3+/-0.1 mag; Proposal Id 12517).

Pike et al. (ATel #15048) combined the NuSTAR position, a ~100 second duration Type-I X-ray Burst, and a preliminary oscillation at 423 Hz (2-sigma confidence), to claim the source in outburst is the accreting millisecond X-ray pulsar SAX J1748.9-2021 (aka NGC 6440 CX-1). Although they note that the 442 Hz spin period of CX-1 differs from the tentative new detection. The optical counterpart of CX-1 is positioned at RA=17:48:52.161 and Dec=-20:21:32.41 (+/-0.15"; Cadelano et al. 2017, ApJ, 844, 53). Although we have never detected a >5-sigma radio source at that position, in our new VLA data we marginally detect a 7.8+/-2.2 muJy source at RA=17:48:52.168 and Dec=-20:21:32.39 with errors of 0.12" and 0.20".

During the VLA observations, MAXI detects a 1-10 keV X-ray luminosity from NGC 6440 of 2e36 erg/s for an 8.5 kpc distance. Assuming a flat spectral index between C- and X-band, VLA J174854.1-202044 and the (marginal) detection of SAX J1748.9-2021 correspond to 5 GHz radio luminosities (L_r = nu L_nu at 5 GHz) of 5e27 and 3e27 erg/s, respectively. Either of these sources would be consistent with a relatively radio quiet neutron star X-ray binary during the decline of an outburst. Given the marginal nature of the association of the NuSTAR source with SAX J1748.9-2021 and the marginal radio detection, we cannot clearly identify that SAX J1748.9-2021 was responsible for the 2021 November outburst in NGC 6440. While there is a strong case that VLA J174854.1-202044 was flaring in the radio, we note that it is 56" from the gravitational centre of NGC 6440 (Pallanca et al. 2021, ApJ, 913, 137), well outside the 6.4" core and just outside the 50" half-light radius of NGC 6440.

We thank the NRAO staff for rapidly scheduling our observations.

NGC 6440
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