The compact central object in the supernova remnant G266.2−1.2

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ABSTRACT

We observed the compact central object CXOU J085201.4−461753 in the supernova remnant G266.2−1.2 (RX J0852.0−4622) with the Chandra ACIS detector in timing mode. The spectrum of this object can be described by a blackbody model with the temperature $kT = 404 \pm 5$ eV and radius of the emitting region $R = 0.28 \pm 0.01$ km at a distance of 1 kpc. Power-law and thermal plasma models do not fit the source spectrum. The spectrum shows a marginally significant feature at 1.68 keV. A search for periodicity yields two candidate periods, about 301 and 33 ms, both significant at a 2.1 $\sigma$ level; the corresponding pulsed fractions are 13% and 9%, respectively. We find no evidence for long-term variability of the source flux, nor do we find extended emission around the central object. We suggest that CXOU J0852.0−461753 is similar to CXOU J232327.9+584842, the central source of the supernova remnant Cas A. It could be either a neutron star with a low or regular magnetic field, slowly accreting from a fossil disk or, more likely, an isolated neutron star with a superstrong magnetic field. In either case, a conservative upper limit on surface temperature of a 10 km radius neutron star is about 90 eV, which suggests accelerated cooling for a reasonable age of a few thousand years.

Subject headings: ISM: individual (G266.2−1.2) — stars: neutron — supernova remnants — X-rays: individual (CXOU J085201.4−461753)

1. INTRODUCTION

The shell-like supernova remnant (SNR) G266.2−1.2 (also known as RX J0852.0−4622, or “Vela Junior”) at the southeast corner of the Vela SNR was discovered by Aschenbach (1998) in the ROSAT All-Sky Survey data. Possible detection of the 1.156 MeV $\gamma$-ray line of the radioactive isotope $^{44}$Ti (half-life ~90 yr) with the Compton Gamma Ray Observatory (Iyudin et al. 1998) may imply a very young SNR age of ~680 yr, at a distance of ~200 pc. Aschenbach, Iyudin, & Schönfelder (1999) estimated upper limits of 1100 yr for the age and 500 pc for the distance. Observations with ASCA (Tsunemi et al. 2000; Slane et al. 2001) demonstrate that the X-ray spectra of the SNR shell are nonthermal. Fits of these spectra with a power-law (PL) model yield a hydrogen column density substantially higher than that for the Vela SNR, implying a plausible distance to the remnant of 1–2 kpc and an age of a few thousand years.

Aschenbach (1998) suggests that G266.2−1.2 was created by a core-collapse supernova that left a compact remnant—a neutron star (NS) or a black hole (BH). Three compact remnant candidates have been reported from the observations with ROSAT (Aschenbach 1998; Aschenbach et al. 1999), ASCA (Slane et al. 2001), and BeppoSAX (Mereghetti 2001). Pavlov et al. (2001) observed G266.2−1.2 with the Chandra Advanced CCD Imaging Spectrometer (ACIS) and found only one bright X-ray source, CXOU J085201.4−461753 (hereafter J0852), close to the SNR center. They measured the source position with accuracy better than 2$''$ and proved that J0852 is not an X-ray counterpart of bright optical stars in the field. Follow-up optical observations (Pavlov et al. 2001; Mereghetti, Pelizzoni, & De Luca 2002b) revealed an object located only 274 southwest of the J0852. The colors of the optical source are consistent with those of a main-sequence star at a distance of 1.5–2.5 kpc; most likely, this is a field star. The limiting optical magnitudes at the position of the X-ray source ($B > 22.5$, Pavlov et al. 2001; $B > 23$, Mereghetti et al. 2002b) rule out the possibility that the X-ray source is an active galactic nucleus (AGN). The lack of variability, combined with the X-ray spectral properties, makes a cataclysmic variable interpretation also plausible. The nature of the source remains elusive, although an isolated cooling NS or a NS with a “fallback” disk seem to be possible interpretations.

The large frame time, 3.24 s, of the previous snapshot (3 ks) ACIS observation made it impossible to search for short periods and led to strong saturation (pileup) of the source image, precluding an accurate spectral analysis. To search for pulsations from the compact source and obtain a more accurate spectrum, we observed J0852 with Chandra ACIS with a time resolution of 2.85 ms. We present the results of this observation in § 2 and discuss the nature of the source in § 3.

2. OBSERVATION AND DATA ANALYSIS

J0852 was observed with ACIS-S3 in continuous clocking (CC) mode on 2001 August 30 (31.5 ks total exposure). CC mode allows one to achieve time resolution of 2.85 ms at the expense of spatial information in one dimension. There were no substantial “background flares” during the observation, so we do not exclude any time intervals from the analysis. For data reduction and analysis, we used CIAO 2.2.1 (CALDB 2.7) and XSPEC version 11.0.

The FWHM of the one-dimensional source image is 0.7$''$, consistent with the ACIS point-spread function. No evidence for excess emission around the point source is seen above the background of 0.013 counts s$^{-1}$ per 1$''$ segment of the one-dimensional image (equivalent to an average surface brightness of 0.025 counts ks$^{-1}$ arcsec$^{-2}$).
2.1. Spectral Analysis

For the spectral analysis we extracted 11,450 source plus background counts from a 4" segment of the one-dimensional image. The background was taken from two adjacent 10" segments. The background-subtracted source count rate is 0.313 ± 0.004 counts s⁻¹. Figure 1 shows the pulse-height spectrum in the 0.6–8.0 keV band, grouped into 77 bins with ≥100 source counts per bin. We ignored all counts below 0.6 keV for spectral fitting because of the poorly known ACIS response at lower energies.

Fitting the spectrum with a PL model yields a large photon index $\gamma = 4.32 ± 0.06$ (all uncertainties at a 1 σ confidence level) and a hydrogen column density $n_{\text{H,21}} \equiv n_{\text{H}}/10^{21} \text{ cm}^{-2} = 11.2 ± 0.2$, close to the total Galactic H I column density in this direction, ≈1 $\times$ 10²² cm⁻² (Dickey & Lockman 1990; estimated with the W3NH tool). The quality of the fit is so poor ($\chi^2 = 3.94$ for 74 degrees of freedom [dof]) that this model can be rejected. Thermal plasma emission models (thermal bremsstrahlung and MEKAL with solar abundances) also do not fit the observed spectrum ($\chi^2 = 1.63$ and 14.26 for 74 dof, respectively).

On the contrary, a single blackbody (BB) model fits the spectrum reasonably well ($\chi^2 = 1.13$ for 74 dof; see Fig. 1). It yields a temperature $T = 4.68 ± 0.06$ MK ($kT = 404 ± 5$ eV) and a radius of equivalent emitting sphere $R = (0.28 ± 0.01)d_1$ km, where $d_1 \equiv d/1$ kpc. The bolometric luminosity is $L_{\text{bol}} = (2.5 ± 0.2) \times 10^{32}d_1^2$ ergs s⁻¹. The hydrogen column density, $n_{\text{H,21}} = 3.45 ± 0.15$, considerably exceeds the highest value, $n_{\text{H,21}} = 0.6$, found by Lu & Aschenbach (2000) for the Vela SNR. It indicates that the source is substantially more distant than the Vela pulsar ($d_{\text{Vela}} = 294_{-50}^{+76}$ pc; Caraveo et al. 2001). Adding a PL component to the BB model only marginally improves the fit ($\chi^2 = 1.126$ for 72 dof, vs. 1.130 for 74 dof, for a single BB). The F-test shows that the reduction of $\chi^2$ caused by adding the PL component is significant only at a 66% confidence level.

Fits with the magnetic hydrogen NS atmosphere models (Pavlov et al. 1995) give a lower effective temperature ($kT \approx 270$ eV) and a larger emitting area ($R \approx 1.2d_1$ km). In both BB and H atmosphere fits, the inferred radius is much smaller than the expected NS radius, and the temperature is too high to interpret the detected X-rays as emitted from the whole surface of a uniformly heated isolated NS of a reasonable age.

To constrain the temperature of the entire NS surface, we fitted the spectrum with a two-component BB model. The fits to the ASCA spectra of the outer, brighter parts of the SNR give a range of hydrogen column densities from 1.4 to 5.3 $\times$ 10¹¹ cm⁻² (Slane et al. 2001). To find a conservative upper limit on the surface temperature $T_s$, we fix the column density at $n_{\text{H,21}} = 5.3$, add a soft BB component with $R_s = 10d_1$ km, and fit $T$ and $R$ at different values of $T_s$, increasing $T_s$ until the fit probability falls to 0.1%. This gives an upper limit $T_s \leq 89$ eV, at a 99.9% confidence level. If we fix the column density at $n_{\text{H,21}} = 3.4$ (as obtained for the single BB fit), the limit becomes as low as $T_s \leq 75$ eV.

Although we find no strong spectral lines, there is a hint of a spectral feature at 1.68 keV (see Fig. 1). This feature persists when the data are rebinned with different numbers of counts per bin. We see no anomalies in the data that could explain the feature as an artifact. In particular, we

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1 Additional information on the W3NH tool can be found at http://heasarc.gsfc.nasa.gov.

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**Fig. 1:** Fit of the ACIS-S3 spectrum of J0852 with a blackbody model. The contours correspond to 68%, 90%, and 95% confidence levels. A possible spectral feature is seen at about 1.68 keV.
have ruled out that the feature could be caused by anomalously high values in the bias map for S3 chip (P. Ford 2002, private communication). The shape of the feature resembles the so-called inverse P Cygni profile, which might be associated with accretion. Its width, ~100 eV, might correspond to velocities of accreting material ~0.03c; however, this width is comparable with the spectral resolution of ACIS-S3 around 1.7 keV (Chandra Proposers’ Observatory Guide, version 3.0, § 6.7). The feature is not seen in the background (SNR) spectrum.

2.2. Timing Analysis

For timing analysis, we extracted 10,957 photons from a 2°5 segment centered on J0852 (~89% of these counts are expected to come from the point source). The time span of the observation is \( T_{\text{span}} = 31.5 \) ks. We corrected the event times for telescope dither and Science Instrument Module motion using the approach described by Zavlin et al. (2000). We transformed the corrected times to the solar system barycenter using the *axBars* tool of CIAO.

We used the \( Z^2 \) test (Buccheri et al. 1983) to search for periodic pulsations. We calculated \( Z^2_m \) for \( m = 1–5 \) (where \( m \) is the number of harmonics included) at 10\(^8\) equally spaced frequencies \( f \) in the 0.001–100 Hz range. This corresponds to oversampling by a factor of about 30, compared to the expected width of \( T_{\text{span}} \approx 30 \mu \text{Hz} \) of the \( Z^2_m(f) \) peaks, and guarantees that we miss no peaks. The two most significant peaks we found are at \( f = 3.324231 \) Hz ± 3 Hz (\( P \approx 301 \) ms) and \( f = 30.369484 \) Hz ± 2 \( \mu \)Hz (\( P \approx 33 \) ms). The two most significant \( Z_{m,\text{max}} \) values, \( Z_{4,\text{max}} = 52.9 \) for the 301 ms period and \( Z_{1,\text{max}} = 36.7 \) for the 33 ms period, correspond to 96.7% and 96.8% significance levels, respectively, for the number of independent trials \( N = f_{\text{max}} T_{\text{span}} \approx 3 \times 10^6 \).

The pulsed fractions obtained from the pulse profiles are 13% ± 3% and 9.1% ± 2.5% for the 301 and 33 ms period candidates, respectively. Because of the low significance, we consider 13% as an upper limit for the pulsed fraction.

To search for variability on larger timescales, we binned the data into 200 s bins. Using the Kolmogorov-Smirnov test, the hypothesis that the observed number of counts in the bins come from a Poisson distribution (with the mean of 69,756 counts per bin) cannot be rejected at a 70% confidence level. We have also used the Fourier transform and found no periodic signal with a pulsed fraction larger than 12% in the 1–10 mHz frequency range. Therefore, we find no evidence for long-term variability in the data.

3. DISCUSSION

The X-ray data and optical limits indicate that J0852 is the compact remnant (NS or BH) of the supernova explosion. The X-ray spectral properties and the lack of radio emission (Duncan & Green 2000) suggest that J0852 is not an active pulsar. Furthermore, the *Chandra* observations show no sign of a pulsar wind nebula (PWNe) around the point source. From the 3 ks observation in timed exposure mode (Pavlov et al. 2001), the 3σ upper limit on the PWNe brightness (in counts arcsec\(^{-2}\)) can be estimated as \( 3(b/A)^{1/2} \), where \( b = 0.029 \) counts arcsec\(^{-2}\) is the background surface brightness, and \( A \) is the (unknown) PWNe area. Scaling the area as \( A = 1000.4 A_3 \) arcsec\(^2\) (which corresponds to the transverse size of about \( 5 \times 10^{17} A_3^{1/2} \) cm) and assuming a PL spectrum with a photon index \( \gamma = 1.5–2 \), we obtain an upper limit of (1.3–2.0) \( \times 10^{30} A_3^{-1/2} d_l^{-1} \) ergs s\(^{-1}\) on the PWNe luminosity in the 0.2–10 keV band, for \( n_{\text{H},21} \) in the range of 1.4–5.3.

The observational properties of J0852 strongly resemble those of the other radio-quiet central compact objects (CCOs) in SNRs (see Pavlov et al. 2002a for a review), particularly the CCO in the SNR Cas A (see Murray et al. 2002, and references therein). At least one of these sources, 1E 1207.4–5209, has been proved to be a NS rotating with a period of 424 ms (Zavlin et al. 2000; Pavlov et al. 2002c). A number of possible interpretations of CCOs have been recently discussed by several authors (e.g., Pavlov et al. 2000, 2001, 2002a; Chakrabarty et al. 2001). The limits on X-ray–to–optical flux ratio for J0852 and the Cas A CCO virtually rule out models that involve accretion onto a NS or BH from a binary companion. If these are accreting objects, a more plausible source of accreting matter might be a “fossil disk,” left over after the SN explosion (van Paradijs, Taam, & van den Heuvel 1995). Alternatively, thermal emission from an isolated, cooling NS could explain the observational results. We discuss these two options below.

3.1. Accretion-powered X-Ray Pulsar?

If J0852 is an accreting NS, the observed luminosity, \( L_x \approx 2 \times 10^{32} d_l^2 \) ergs s\(^{-1}\), could be due to a rather low accretion rate, \( \dot{m} \approx 1.5 \times 10^{12} R_6 M_7^{-1} d_l^2 \) g s\(^{-1}\), where \( R_6 = R_{\text{NS}}/(10^6 \) cm), \( M_7 = M_7 / M_\odot \). The accreting matter could be supplied from a fossil (“fallback”) disk. The formation of such a disk from the ejecta produced by a SN explosion was discussed by a number of authors (see, e.g., Marsden, Lingenfelter, & Rothschild 2001, and references therein). Some models suggest that a fossil disk can be formed several days after the SN explosion (“prompt” disk) and range from 0.001 to 0.1 \( M_\odot \), while others suggest that the disk can be formed later, years after the SN explosion (“delayed” disk). The details of the formation mechanism and the disk properties are highly uncertain, and, consequently, the accretion rate \( \dot{m} \) is also poorly constrained, but the required value of \( \approx 10^{12} \) g s\(^{-1}\) is low enough not to exhaust the disk at any reasonable age of J0852.

The accretion onto a NS can proceed in two different regimes (e.g., Frank, King, & Raine 1992), depending on the relation between the corotation radius, \( R_c = 1.5 \times 10^9 P^{2/3} M_7^{-1/3} \) cm, and the magnetospheric radius, \( R_M = 3.5 \times 10^8 B_{12}^{1/2} M_7^{-2/7} M_6^{-1/12} \) cm, where \( P \) is the NS spin period, \( B = 10^B \) G is the magnetic field at the NS surface, and \( M_6 = M/(10^6 \) g s\(^{-1}\)). If \( R_M > R_c \), the infalling material is stopped at the magnetospheric radius and expelled as a wind by centrifugal force. In this “propeller regime” (Illarionov & Sunyaev 1975), X-ray emission is mainly due to optically thin thermal bremsstrahlung produced in the flow (Wang & Robertson 1985). Because the thermal bremsstrahlung model does not fit the observed spectrum, we consider this case unlikely. If \( R_M < R_c \) (i.e., \( P \gtrsim 10^P B_{12}^{1/2} M_6^{-2/7} M_7^{-5/7} R_{18/7} \) s, or \( B _{12} \lesssim 4 \times 10^9 \) G), the accreting matter is able to reach the NS surface. At extremely low magnetic fields, \( B \lesssim 6 \times 10^6 M_7^{-1/2} R_6^{-1/4} \) G, when the magnetospheric radius is smaller than the NS radius, a hot layer is...
formed at the boundary between the accretion disk and the NS surface (e.g., Frank et al. 1992). Because this boundary layer is expected to be optically thin at \( m \ll 10^{16} \text{ g s}^{-1} \) (Inogamov & Sunyaev 1999), its radiation cannot explain the observed BB spectrum. At reasonable magnetic fields, \( B > 10^7 \text{ G} \), the accretion flow is channeled onto the NS poles, producing hot spots of radius \( a \sim R_{\text{NS}}/R_{\text{M}} \sim 0.17 \beta d_2/10^{12} \text{ R}_\odot/10^{14} \text{ km} \). The observed size and temperature of the BB-like radiation are consistent with being emitted from such a cap at \( B \sim 10^{11} \text{ G} \). Such an estimate requires a pulsar period \( P \geq 10^8 \text{ s} \), much longer than our candidate periods. If we assume \( P = 301 \text{ ms} \), the condition \( R_{\text{M}} < R_{\text{NS}} \) requires \( B \leq 10^7 \beta d_2/10^{12} \text{ G} \) and \( a \geq 1.2 \beta d_2/10^{12} \text{ km} \), considerably larger than the size of emitting region, \( R \approx 0.3 d_1 \text{ km} \), inferred from the BB fit. However, given the crudeness of the polar cap size estimate, which can be much smaller than adopted above (see, e.g., Frank et al. 1992, and references therein), we cannot rule out the candidate period of 301 ms based on the apparent inconsistency between \( a \) and \( R \). Thus, in the accretion hypothesis, J0852 could be a low-luminosity X-ray pulsar, presumably with a magnetic field much lower than those of binary X-ray pulsars, slowly accreting from a fossil disk. An argument against this interpretation is a lack of nonperiodic variability in the radiation from J0852, which is commonly observed from accreting sources (at least, X-ray binaries). On the other hand, variability could be found in further observations of this source. A direct confirmation of the accreting hypothesis would be detection of an accretion disk, which would require deep IR-optical observations with high angular resolution.

3.2. Isolated Cooling Neutron Star?

One can also assume that J0852 is an isolated (nonaccreting) NS emitting thermal radiation from its surface. The “standard” NS cooling models predict a luminosity of \( \sim (0.5–2) \times 10^{34} \text{ ergs s}^{-1} \) for a NS of 0.1–10 kyr age (e.g., Tsuruta 1998). The lower observed luminosity of J0852 could be interpreted as due to an accelerated cooling mechanism, but applicability of the cooling models to J0852 is questionable because the models assume a uniformly heated NS surface, while the size of the emitting region obtained from the BB fit is only \( \sim 0.3 d_1 \text{ km} \).

Apparent sizes of the emitting regions much smaller than the canonical NS radius have been observed from other isolated NSs (Pavlov et al. 2002a, 2002b). In particular, the Cas A CCO shows a (blackbody) size of 0.3 km with a temperature of 0.6 keV (Pavlov et al. 2000), which hints that it is an object similar to J0852, with a higher temperature possibly due to its younger age. Pavlov et al. (2000) suggested a two-component thermal model for the Cas A CCO, in which the observed X-rays are emitted from hydrogen polar caps of about 1 km radius and 0.24 keV effective temperature, while the rest of the NS surface is iron at a temperature of 0.15 keV, too cold to be observable because of strong interstellar absorption. In this model, the polar caps are hotter because of the higher thermal conductivity of hydrogen. Weaker ISM absorption for J0852 allowed us to find a lower temperature limit for the cold component, less than 90 eV, too low to explain the temperature difference by different chemical compositions. It should be mentioned that this limit is a factor of 1.4 lower than the temperature predicted by the so-called standard (slow) cooling model for a 10^3 yr old NS (see, e.g., Fig. 4 in Slane, Helfand, & Murray 2002). This may indicate that if J0852 is a NS, it undergoes fast cooling, perhaps associated with direct Urca processes in the NS core (e.g., Yakovlev et al. 2002).

Hot spots on the NS surface could also be associated with a very strong magnetic field, \( B \geq 10^{13} \text{ G} \). As a result of anisotropic heat conductivity of the NS crust, the surface temperature is higher at the magnetic poles (Greenstein & Hartke 1983; Shibanov & Yakovlev 1996). To produce small hot spots, the surface magnetic field should be strongly nonuniform (e.g., an offset dipole or a quadrupole; Page & Sergeant 1996). Fast decay of a superstrong magnetic field \( (B \geq 10^{14} \text{ G}) \) could provide an additional source of polar cap heating (Thompson & Duncan 1996; Colpi, Geppert, & Page 2000). In such strong magnetic fields, electron-positron pair creation should be suppressed because of photon splitting (Baring & Harding 2001), which is consistent with the apparent lack of pulsar activity in J0852.

One can crudely estimate the magnetic field assuming that one of the two candidate periods, 33 or 301 ms, is the true period. If the initial period of the pulsar was much shorter than the current period, then the period derivative, rotation energy loss rate, and “canonical” magnetic field \( B = 3.2 \times 10^{10} \beta d_2 \text{ G} \), can be estimated as \( P = 3.2 \times 10^{-11} t_1 \text{ yr} \), \( E = 1.25 \times 10^{36} P_3^{-2} \text{ ergs s}^{-1} \), \( B = 1.8 \times 10^{12} P_3^{-1/2} \text{ G} \), where \( t_1 \text{ yr} \) is the NS age, and \( n \) is the braking index. Assuming \( n = 2.5 \) (close to that observed in young pulsars), we obtain, for \( P = 33 \text{ ms} \), \( P = 7.0 \times 10^{-13} t_1^{-1} \text{ yr} \), \( E = 8.6 \times 10^{38} t_1^{-1} \text{ ergs s}^{-1} \), and \( B = 4.9 \times 10^{13} t_1^{-1/2} \text{ G} \). Because the local magnetic field can be much higher than the canonical value (e.g., for an offset dipole), one can speculate that, for \( P = 301 \text{ ms} \), it is high enough to explain the hot spot(s) and the lack of radio-pulsar activity. If this hypothesis is correct, the J0852 could be a very young anomalous X-ray pulsar (AXP) whose period will become of order 6–12 s (as observed in AXPs) when it grows older by a factor of 20–40.

However, there are considerable differences between the properties of AXPs and J0852. Contrary to AXPs, whose spectra contain both the BB and PL components of comparable luminosities (Mereghetti et al. 2002a), the spectrum of J0852 fits well with a single BB model. The size of the emitting region in J0852 is substantially smaller (0.3 km vs. 0.7–5 km), and the temperature somewhat lower (0.4 keV vs. 0.4–0.6 keV), than those of AXPs. These differences (particularly, the lack of a PL component in J0852) hint at different NS parameters. For instance, it is quite possible that none of the candidate periods is correct, and the true period is even longer than the AXP periods. In this case, the magnetic field could be even higher than those adopted in the magnetar interpretation of AXPs—e.g., \( B = 2.4 \times 10^{15} \text{ G} \), \( f_1 \text{ yr} \). Such a strong field can inhibit not only the pair cascade, but also the emission of primary particles from the NS surface, which might explain the lack of particles in the NS magnetosphere (hence, the lack of nonthermal radiation) in J0852. If the NS rotates sufficiently slowly, \( P \geq 0.5 B_{15}^{1/2} \text{ ergs s}^{-1} \), the critical parallel electric field required to pull out electrons from the NS surface, \( E_{\text{crit}} \approx 2.7 \times 10^{12} \text{ V cm}^{-1} \), is higher than the maximum parallel electric field at the surface,
\[ E_{\text{max}} \approx 1 \times 10^{10} B_{15} (P/20 \text{ s})^{-3/2} \text{ V cm}^{-1}. \] On the other hand, the surface temperature, \( kT_e \approx 0.5(Z/26)^{4/5} B_{15}^{2/5} \) keV, above which the thermionic emission of electrons becomes efficient (Usov & Melrose 1995), grows with increasing magnetic field. (These estimates assume the NS has no light-element [e.g., hydrogen] atmosphere.) Therefore, a long period and a superstrong magnetic field might explain the lack of the PL tail in the spectrum of J0852 and other enigmatic CCOs (e.g., in the Cas A and Pup A SNRs; Pavlov et al. 2002a).

In summary, the observations of J0852 can be explained, assuming it is a NS. Given the deep limiting optical magnitudes and the lack of nonperiodic variability, we consider the interpretation in terms of an isolated NS with a very strong magnetic field somewhat more plausible than the accretion models. Further observations are required to confirm or reject this hypothesis. Particularly important would be X-ray timing observations to measure the period unequivocally, high-resolution X-ray spectral observations to look for spectral features, and IR-optical observations to search for a NS counterpart (e.g., a fossil disk).

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\[ P_{\text{obs}} = \frac{1}{C_2 5^{25}} \left( \frac{V_c}{C_0} \right)^{3/2}. \]

\[ B = 15^{P = 20 \text{ s}} / C_0 \]

\[ kT_e \approx 0.5(Z/26)^{4/5} B_{15}^{2/5} \] keV, above which the thermionic emission of electrons becomes efficient (Usov & Melrose 1995), grows with increasing magnetic field. (These estimates assume the NS has no light-element [e.g., hydrogen] atmosphere.) Therefore, a long period and a superstrong magnetic field might explain the lack of the PL tail in the spectrum of J0852 and other enigmatic CCOs (e.g., in the Cas A and Pup A SNRs; Pavlov et al. 2002a).

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\[ P_{\text{obs}} = \frac{1}{C_2 5^{25}} \left( \frac{V_c}{C_0} \right)^{3/2}. \]

\[ B = 15^{P = 20 \text{ s}} / C_0 \]

\[ kT_e \approx 0.5(Z/26)^{4/5} B_{15}^{2/5} \] keV, above which the thermionic emission of electrons becomes efficient (Usov & Melrose 1995), grows with increasing magnetic field. (These estimates assume the NS has no light-element [e.g., hydrogen] atmosphere.) Therefore, a long period and a superstrong magnetic field might explain the lack of the PL tail in the spectrum of J0852 and other enigmatic CCOs (e.g., in the Cas A and Pup A SNRs; Pavlov et al. 2002a).

In summary, the observations of J0852 can be explained, assuming it is a NS. Given the deep limiting optical magnitudes and the lack of nonperiodic variability, we consider the interpretation in terms of an isolated NS with a very strong magnetic field somewhat more plausible than the accretion models. Further observations are required to confirm or reject this hypothesis. Particularly important would be X-ray timing observations to measure the period unequivocally, high-resolution X-ray spectral observations to look for spectral features, and IR-optical observations to search for a NS counterpart (e.g., a fossil disk).

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