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Connection between the Supernova Remnant G284.3-1.8 and the Gamma-ray Binary 1FGL J1018.6-5856: Implications from X-ray Observations with Suzaku

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G284.3−1.8, also known as MSH 10-53, is a supernova remnant (SNR) with a radio shell (e.g., Milne et al. 1989) and thermal X-ray emission (e.g., Williams et al. 2015). Near the center of the SNR is the gamma-ray binary 1FGL J1018.6−5856, which was discovered in high-energy gamma rays by the Fermi Large Area Telescope (Fermi LAT Collaboration 2012). Follow-up observations found X-ray emission (Fermi LAT Collaboration 2012) and also very-high-energy gamma rays (H.E.S.S. Collaboration 2016) from the binary system. The positional coincidence between the SNR and binary is suggestive of a possible physical association between the two systems. We analyzed Suzaku X-ray data of the SNR G284.3−1.8 to clarify its relation with 1FGL J1018.6−5856. In the spectral analysis, the X-ray absorption column density of G284.3−1.8 was found to be $N_{\rm H} \sim 7 \times 10^{21}$ cm^{-2}. The value agrees well with that of 1FGL J1018.6−5856, indicating that the two systems are located at the same distances. The X-ray spectrum of G284.3−1.8 is characterized by the strong Mg K-shell line emission. The obtained Mg/Ne mass ratio is $M_{\rm Mg}/M_{\rm Ne} = 0.84 \pm 0.06$, making it categorized as one of the Mg-rich SNRs. Recent studies of Mg-rich SNRs such as N49B (Sato et al. 2024) and G359.0−0.9 (Matsunaga et al. 2024) suggested that Mg-rich ejecta can be realized by a destratification process inside the progenitor star, the so-called shell merger process (e.g., Yadav et al. 2020). In this process, O-burning or Ne-burning shell is merged with an outer shell before the core-collapse, which results in a higher Mg/Ne ratio. Applying the same scenario to the case of G284.3−1.8, the initial mass of its progenitor is estimated to be $M_{\rm ZAMS} < 15 M_{\odot}$. The estimated mass indicates that the supernova explosion should have left behind a neutron star. The stable orbital modulation of 1FGL J1018.6−5856, on the other hand, would be best reproduced in a scenario where its compact object is a pulsar and particles are accelerated at a shock formed by the collision between the pulsar wind and the stellar wind. Therefore, our result suggests that G284.3−1.8 and 1FGL J1018.6−5856 are both remnants of a common supernova explosion.

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