Magnetic field of the slowest rotating neutron star in the symbiotic X-ray binary 4U 1954+319†

T. Enoto[*1,*2,*3], M. Sasano,[*4] S. Yamada,[*5] T. Tamagawa,[*1]
K. Makishima[*4,*6], and Suzaku 4U 1954+319 Analysis Team

Neutron stars (NSs) are not boring degenerate compact objects with a uniform face, but exhibit a large variety of observational diversities mainly due to a wide range of magnetic field (B-field, $\sim 10^4$–10^{12} T), rotation spin period ($P \sim 10^{-3}$–10^4 s), and (in some cases) mass accretion from a companion star. Binary systems with NSs are conventionally classified into high-mass X-ray binaries (HMXBs, an optical counterpart mass $M_c > 10 M_\odot$) or low-mass X-ray binaries (LMXBs, $M_c < 1$–$2 M_\odot$). The former and latter are thought to host NSs with higher and lower B-field of 10^{7-8} T and 10^{4-6} T, respectively. However, the symbiotic X-ray binary (SyXB) 4U 1954+319 was recently recognized as a rare system hosting a peculiar NS and M-type companion, and found to be the slowest rotator among known X-ray pulsars with $P \sim$5.4 h.

We performed two observations of 4U 1954+319 with the X-ray satellite *Suzaku* in 2011 (quiescent) and 2012 (flare phase), and investigated the spectral and temporal nature of this peculiar system. Although the optical counterpart is classified as a "low mass" star, its X-ray features are quite similar to a wind-fed type

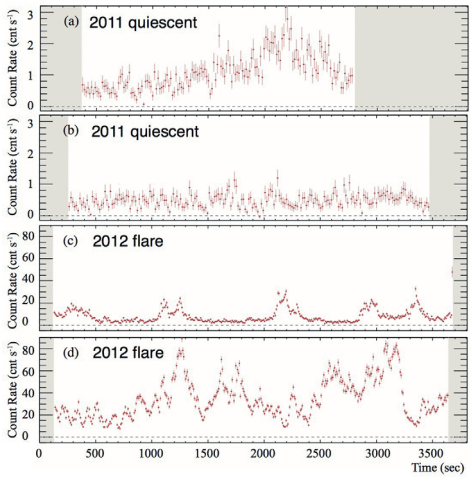

Fig. 1. The 1–10 keV X-ray count rates of 4U 1954+319 observed with X-ray CCD instruments (X-ray Imaging Spectrometer) on board the Suzaku satellite[1)], during a quiescent state (panel a and b) and an outburst (c and d) in 2011 and 2012, respectively.

† Condensed from the article in the Astrophysical Journal **786**, 127 (2014)

*1 RIKEN Nishina Center
*2 JSPS SPD Fellow
*3 NASA Goddard Space Flight Center
*4 Department of Physics, University of Tokyo
*5 Department of Physics, Tokyo Metropolitan University
*6 RIKEN MAXI Team

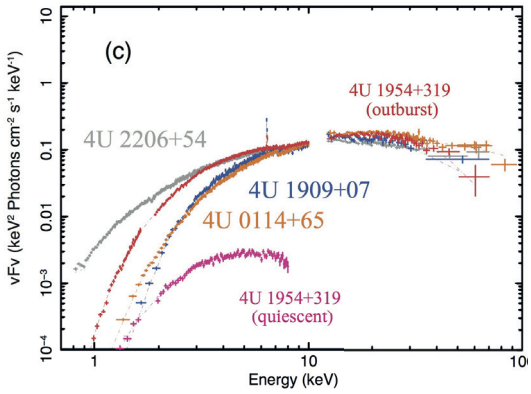

Fig. 2. Spectral comparison of 4U 1954+319 with other long period pulsars in HMXBs (modified from Enoto et al., 2014[1)]).

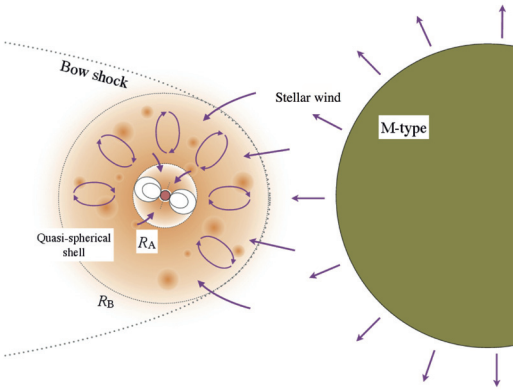

Fig. 3. Schematic view of the quasi-spherical accretion from stellar wind in the X-ray binary 4U 1954+319[1)].

HMXB system; e.g., 1) high pulsed fraction, ∼60–80%, 2) shot-like mass accretion, characterized by the log-normal distribution of the count rate (Fig.1), 3) broad-band spectral similarity to low-luminosity slowly rotating NSs in HMXBs (Fig. 2), and 4) a narrow 6.4 keV Fe-Kα line. Combined with a sign of the spin-equilibrium over a long time scale, we proposed a quasi-spherical accretion regime from a slow stellar wind from the M-type companion (Fig. 3). Even though we do not need an extremely strong B-field like magnetars, which were expected from the canonical disk-type accretion, we still need a higher B-field in the range of 10^{8-9} T as the HMXB-NSs rather than the LMXB-NSs. Our study indicates a new interesting subclass of X-ray pulsars, i.e., SyXBs, and casts a question on its evolutionary path to make such a peculiar system.

References

1) T. Enoto, M. Sasano, et al: ApJ, **786**, 127 (2014)