学位論文要旨（修士（理学））

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論文題名：Understanding the shock wave of stellar wind collision in the massive binary WR140 using X-ray spectroscopy

邦題：X 線分光解析による大質量連星系 WR140 の星風衝突衝撃波の理解（英文）

We analyze a series of data of the Wolf-Rayet (WR) star binary WR140 that encompasses one entire orbit of ~8 years, taken with the Reflection Grating Spectrometer (RGS) onboard the European X-ray observatory *XMM-Newton* that has been operational in-orbit since 2000. We find that the RGS detects X-rays from optically-thin thermal plasma only during orbital phases when the companion O star is on the near side of the WR star. We evaluate the spectra of Ne, O and Fe emission lines, and find that the temperature of the plasma producing Ne, O and Fe emission lines is 0.4-0.8, 0.21-0.23, and 0.83-0.89 keV, respectively. We also find that their line-of-sight velocities v_{los} and their dispersions σ_{los} are mutually consistent at all phases. The absolute values $|v_{los}|$ and σ_{los} of Ne, which varies from 600 to 1200 km s^{-1} and from 400 to 700 km s^{-1} with the orbital phase, respectively, appear to be the largest and smallest, respectively, between phase 0.968 and phase 0.935, where the inferior conjunction of the O star occurs. We perform a density diagnosis using the intensity ratios of the He-like triplet of Ne, O, and those of emission lines at 17.10 Å, 17.05 Å and 16.78 Å of Fe_{XVII}. At orbital phases 0.816 and 0.912, we measured, for the first time the electron number density of the Ne line-emission site to be approximately 10^{12} cm^{-3} from the He-like triplet of Ne. The upper limit of the electron number density with the O He-like triplet is approximately 10^{10}-10^{12} cm^{-3} at phases 0.816, 0.912 and 0.935. For Fe, due to statistical limitations, we are unable to obtain any constraint on the electron number density. We find that photo-excitation rate of the He-like triplet of Ne by extreme ultra violet lights from the O star is only 0.7-9.6 per cent of that of the collisional excitation at orbital phase 0.816. This implies that our density measurement under the assumption that only the collisional excitation works is reliable at this orbital phase.

We calculated the shock cone shape analytically, and successfully identify for the first time the distances of the Ne and O line-emission site from the shock stagnation point using the observed ratios of the line-of-sight velocities $|v_{los}|$ and their dispersions σ_{los}. We also calculate, in addition to ratios $|v_{los}|/\sigma_{los}$, v_{los} and σ_{los} separately to identify the line-emission site of Ne and O. The resultant distance ranges from 1×10^{13} cm (phase 0.987) to 13×10^{13} cm (phase 0.816) from the stagnation point. At the earlier orbital phases 0.816, 0.912 and 0.935, we discovered turbulent broadening of the Ne line, whose

velocity dispersion σ_{turb} is as large as 3.9 to 6.2×10^7 cm s^{-1} at phase 0.816. Similar but slightly smaller σ_{turb} is detected with Ne emission lines from later orbital phases 0.912 and 0.935 whereas only upper limits on σ_{turb} is obtained with Ne emission lines at phases close to the periastron 0.968 and 0.987. The similar tendency is found from O emission lines. The turbulent velocity dispersion σ_{turb} of the O lines is as large as 4.0 to 6.6×10^7 cm s^{-1} at phase 0.816. Synthesizing σ_{turb} from all phases, we may find a sign of the growth of the turbulence as the plasma flows along the shock cone.