Hitomi observation of the Perseus cluster

– gas motions and resonant scattering –

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Abstract

Hitomi SXS (Hitomi; Takahashi et al. 2016, Proc. SPIE, 9905, 99050U, SXS; Kelley et al. 2016, Proc. SPIE, 9905, 99050V) first allow us to investigate fine structures of emission lines from highly ionized ions with its high energy resolution of ∼5 eV at 6 keV in orbit. The line diagnostics make it possible to measure streaming and turbulent gas motions, which play key roles for understanding the basic physical properties of the intra-cluster medium (ICM) in galaxy clusters, such as the thermal conductivity and viscosity. Particularly in the cluster core, resonance scattering should be taken into account when inferring physical properties from line intensities because the optical depth of the He-α resonant line is expected to be larger than 1 (e.g., Zhuravleva et al., MNRAS, 2013).

Hitomi SXS carried out a series of 4 overlapping pointing observations of the Perseus cluster during the Hitomi performance verification phase with a total 300 ksec. Hitomi SXS finds an extremely quiescent atmosphere in the ICM of the Perseus cluster core where the gas has a line-of-sight velocity dispersion below 200 km sec^{-1} (Hitomi collaboration, Nature, 2016). Also, the line-of-sight velocity map across the 60 kpc image of the cluster core shows a relative gradient of 150 ± 70 km sec^{-1}. These suggest that the cluster mass measurement under the assumption of hydrostatic equilibrium would be little affected by turbulent pressure. On the other hand, the observed line flux ratio of Fe XXV He-α resonant to forbidden lines is found to be lower in the cluster core when compared to the outer region where the observed spectrum shows a typical optically thin plasma feature, consistent with resonant scattering of the resonant line and also in support of the low turbulent velocity. We also compare the observed line flux ratios such as Fe He-α resonant, forbidden, He-β, and Ly-α with the expected ones from the Monte-Carlo simulation of resonant scattering in the Perseus cluster core. The line ratios derived from the observation and simulations in the cluster core almost agree with each other within statistical and systematic errors.

Key words: galaxies: clusters: individual (Perseus cluster) – galaxies: clusters: intracluster medium – X-rays: galaxies: clusters