Possibility of Systematic Study of Supernova Explosions by Nuclear Imaging Spectroscopy

Yoshitaka Mizumura¹,², Toru Tanimori², Atsushi Takada², on behalf of SMILE group³
¹ Unit of Synergetic Studies for Space, Kyoto University, Kyoto, Japan
² Division of Physics and Astronomy, Kyoto University, Kyoto, Japan
³ http://www-cr.scphys.kyoto-u.ac.jp/research/MeV-gamma/wiki/wiki.cgi

All-sky nuclear imaging spectroscopy is a promising tool for systematic study of supernova (SN) explosions. Especially, progenitor scenarios of type Ia SNe are not well-understood yet. Here, we report an nuclear imaging telescope, Electron-Tracking Compton Camera (ETCC), and its expected performance with satellite-based all-sky imaging, which enables us to observe supernova lines from SN Ia at a distance beyond 40 Mpc (~several SNe/years).

1. Progenitor scenarios of Ia SNe

Mass accretion from companion star (SD) or Co-existence?

Violent merger of white dwarfs (DD)

Nuclear gamma-ray is a powerful tool to distinguish SD and DD.

SN2014J: SN Ia@3.5Mpc (Very rare: ~1/40 SN/yr) INTEGRAL successfully observed ⁵⁶Ni and ⁵⁶Co lines, but it is difficult to resolve the puzzle of SD vs. DD.

True nuclear imaging spectroscopy and systematic study are required!!

2. Nuclear imaging spectroscopy w/ ETCC

Expected performance Instruments on satellite: 4 x (50 cm)³ ETCC Effective Area: 240 cm²@1 MeV PSF: 2° @1 MeV ΔE/E: 5%@662 keV Field of View: 2π sr Effective Exposure: 33% Assumed B.G. flux: 2 times of reported flux

Details in [23-PS.278]
Please check also SMILE balloon experiment series. Sub-MeV gamma-ray Imaging Loaded-on-balloon Experiment

3. Detectable nuclear gamma-ray lines

SD

DD

SN Ia@3.5Mpc

56Co lines will be observed from ~several SNe/years

4. Averaged lightcurve of type Ia SNe

Emulation of type Ia SNe SN Ia rate(60 Mpc): ~2×10⁻⁵ [yr⁻¹ Mpc⁻³] Flux uncertainty: ⁵⁶Ni gen. 20% (SD & DD) Inclination 30% (only DD)


5. Detection limits & prospects

Conservative model: 2xBG, All-sky survey Optimistic model: 1xBG, Pointing mode

If we achieve observations of Ia SNe up to 100 Mpc, >400 SNe/Syrs are expected.

Nuclear imaging spectroscopy with ETCC enables us to try systematic observational studies of type Ia SNe, and it will open a new era of nuclear physics in the cosmos.

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