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Gamma-Rays from SN2014J and their Implications for Type Ia Supernovae[1]

ROLAND DIEHL, Max Planck Institut für extraterrestrische Physik, Garching, Germany

Gamma-ray lines from radioactive decay of unstable isotopes which are co-produced by nucleosynthesis are being measured with ESA's INTEGRAL space mission and its gamma-ray spectrometer SPI. ^{56}Ni is produced in large amounts in supernova explosions, and its decay through ^{56}Co (within $\sim$ 8 days) and then to ^{56}Fe (within $\sim$ 111 days) provides the energy source for the supernova light seen at optical wavelengths. Measuring the primary gamma-rays from the ^{56}Ni decay chain had been a long-standing objective for gamma-ray astronomy, and could be realized now with supernova SN2014J, the closest Type Ia supernova since space-based gamma-ray astronomy had been established. For the first time, the main characteristic decay lines from ^{56}Co at 847 and 1238 keV were clearly seen, and confirm our basic understanding of Type Ia supernovae being the result of a disintegrating a white dwarf star, and the thermonuclear runaway explosion producing about half a solar mass of the radioactive ^{56}Ni isotope. The INTEGRAL spectrometer data allow line shape determinations, and thus constrain velocity of the ^{56}Ni ejecta and their decay products. The gamma-ray line signature of the ^{56}Co decay lines found from SPI measurements during the months when the supernova unfolds and becomes transparent to these gamma-rays is less regular than expected and points to a non-spherical explosion. Moreover, the surprising detection of early ^{56}Ni decay lines long before the supernova was expected to be transparent to gamma-rays suggests that a primary thermonuclear ignition of the white dwarf surface region has occurred, possibly causing the runaway explosion. We discuss how these indications fit into the current understanding of the variety of supernova Type Ia explosion models, and the various constraints we have by now on this nearby event from other astronomical windows.

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