The Seventh Pacific Rim Conference on Stellar Astrophysics
ASP Conference Series, Vol. 362, 2007
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Origin of Sgr A East: Hypernova?

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Abstract. We have observed H_2 $1-0$ S(1) (2.1218μm) and $2-1$ S(1) (2.2477μm) emission line spectra from the interaction regions between Sgr A East and the surrounding molecular clouds in the central 10 pc of the Galaxy. From the shock velocities ($\simeq$ 100 km s^{-1}) of Sgr A East, estimated by comparing H_2 line profiles with those of NH_3, we derive an initial explosion energy of 0.2-4 $\times 10^{53}$ ergs. Such a high range energy excludes the hypothesis of a single typical supernova for the origin of Sgr A East. Instead, we suggest a collapsar or microquasar.

Sgr A East is believed to play an essential role in the structure and kinematics in the central 10 pc of our Galaxy. However, the exact nature of Sgr A East is still controversial. The object has frequently been interpreted as a supernova (SN) remnant (Goss et al. 1983; Maeda et al. 2002; Herrnstein & Ho 2005). Some investigators, however, have suggested that the energy ($\sim 10^{52}$ ergs), size, and elongated morphology of Sgr A East cannot have been produced by a typical SN (Yusef-Zadeh & Morris 1987; Mezger et al. 1989; Fatuzzo et al. 1999).

The energy required to make the Sgr A East shell is the key parameter and can be directly measured by studying the interaction of Sgr A East with the ambient material. We observed H_2 spectra from the interaction regions between Sgr A East and the surrounding molecular clouds (the 50 km s^{-1} cloud, the northern ridge, the molecular ridge, the southern streamer, and the western streamer) using the long-slit Cooled Grating Spectrometer 4 with an echelle grating at the United Kingdom Infrared Telescope (UKIRT). The H_2 $1-0$ S(1) data cube was directly compared with the NH_3(3,3) data from McGary, Coil & Ho (2001) to investigate the gas kinematics.

Shocks are the major contributor to the H_2 excitation (Lee et al. 2003). Assuming continuous (C-) shocks in very strong magnetic fields, we derive shock velocities of about 100 km s^{-1} by comparing H_2 line profiles, which trace post-shock gas, with those of NH_3, which trace pre-shock gas in molecular clouds. We estimate the initial explosion energy of Sgr A East from the shock velocities using a standard model of SNR evolution (Shull 1980). The lower limit of the energy is (2–3) $\times 10^{52}$ ergs under the assumption that the Sgr A East supernova exploded in a low density halo, and the upper limit is (2–4) $\times 10^{53}$ ergs if it exploded within a dense giant molecular cloud.

This range of energies excludes the hypothesis of a single, typical, SN for the origin of Sgr A East. The tidal disruption of a star by the super massive black hole, Sgr A* (Khokhlov & Melia 1996), multiple SNe, or a hypernova are possible ways of generating such high explosion energies. However, tidal disruption cannot explain the metallicity (Maeda et al. 2002) and the 3-D geometry of the remnant and the multiple SNe scenario needs much longer time than the age of Sgr A East. A hypernova, which is believed to originate from a collapsar or microquasar, appears to be the most probable origin.

Acknowledgments. The UKIRT is operated by the Joint Astronomy Centre on behalf of the U.K. Particle Physics and Astronomy Council. TRG's research is supported by the Gemini Observatory, which is operated by the Association of Universities for Research in Astronomy, Inc., on behalf of the international Gemini partnership of Argentina, Australia, Brazil, Canada, Chile, the United Kingdom and the United States of America.

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