

Shaping the Galactic Centre Molecular Zone (CMZ): Hydrodynamical Simulations of Sgr A* Feedback

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Abstract

The Central Molecular Zone (CMZ) is a dense molecular gas reservoir in the central few hundred parsecs of the Milky Way. Its eccentric and asymmetric structure has been highly influenced by Galactic bar dynamics, self-gravity, stellar feedback and past nuclear activity. Evidence for energetic activity in the Galactic Centre motivates the question of whether outbursts from Sgr A* can further perturb an established CMZ. We investigate this possibility using three-dimensional hydrodynamical simulations with AREPO, modelling a self-gravitating, radiatively cooling gas ring of mass $10^8 M_\odot$ in a fixed Galactic potential. We implement finite-duration AGN feedback through equal thermal and kinetic energy injection within 30 pc, exploring Eddington ratios of 0.1–1.0, coupling efficiencies of 0.15–1.0 and outburst durations of 0.5–10 Myr.

In the fiducial model, an outburst with an Eddington ratio of 0.3, coupling efficiency of 0.3 and duration of approximately 1 Myr drives the ring into a substantially more eccentric and asymmetric configuration, reaching a second-moment eccentricity of $e \simeq 0.65$ and remaining near $e \simeq 0.6$ at later times. The ring expands from approximately 115 to 147 pc before contracting, while its vertical extent temporarily increases to about 40 pc before radiative cooling allows it to flatten to approximately 10 pc. The positive-to-negative longitude mass ratio reaches 1.7–1.9, and the gas develops a small inclination relative to the Galactic plane. Synthetic longitude–velocity distributions become broader and more asymmetric, with extended velocity structures broadly consistent with the observed NOBEYAMA ^{12}CO envelope. Longer outbursts and stronger feedback produce more pronounced radial redistribution and velocity dispersion. These results suggest that a finite-duration outburst from Sgr A* can perturb an established CMZ on Myr timescales, contributing to its eccentricity and asymmetry alongside bar dynamics, self-gravity and stellar feedback.