Outflows from Super Star Clusters in Starbursts

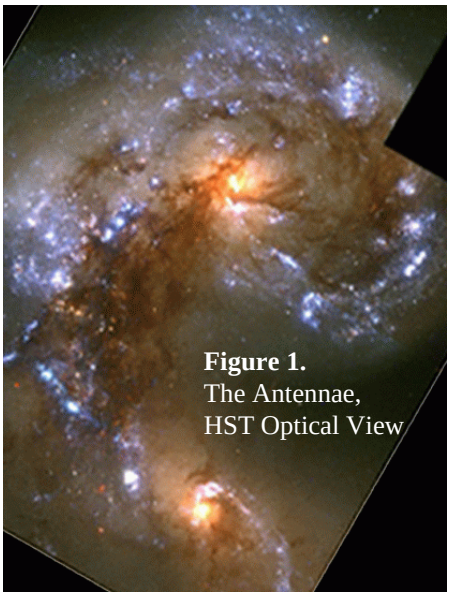

Figure 1.
The Antennae,
HST Optical View

Superwind Engines in Starbursts

Intense star formation produces super star clusters (SSCs), which may be progenitors of globular clusters (GCs). SSCs are so called because they are as massive (10^5-10^6 $M_\odot$) and compact (radii of a few pc) as GCs, but much brighter since they are young. High-resolution near-IR spectroscopy of the youngest SSCs in the nearest starburst merger, the Antennae Galaxy (Fig. 1), reveals that these clusters drive mass-loaded supersonic outflows powered by stellar winds and supernovae. The combined outflows of many SSCs heat and clear away surrounding cool gas, ultimately producing a galactic-scale superwind if conditions are favorable (e.g. cluster density, total mass-loss rate, and relative galactic potential well depth).

Energetics of SSC Outflows

The broad Brγ line profiles of the youngest SSCs are not Gaussian; their high-velocity wings and pointy peaks are well fit by a β-law profile, assuming a constant mass-loss rate (dM/dt) and a power-law velocity flow that approaches a terminal value. Inferred values of dM/dt are 0.01-1 $M_\odot$ /yr, comparable to current star-formation rates but up to 25 times greater than expected due to stellar mass loss. SSC outflows are strongly mass-loaded. Observed momentum fluxes in the Brγ-emitting gas agree fairly well with predicted values, suggesting that the outflows are momentum driven (Fig 2). The kinetic energies and mechanical luminosities of the flows are not well-probed by 10^4 K gas, however, indicating that the bulk of energy is in another phase. Thermal energies of recombining and X-ray-emitting hot gas also make small contributions to the total energy; most of the outflow mechanical energy is efficiently thermalized in the kinetic energy of hot gas. These are properties shared with galactic scale superwinds, which may be the ultimate evolutionary state of the Antennae starburst.

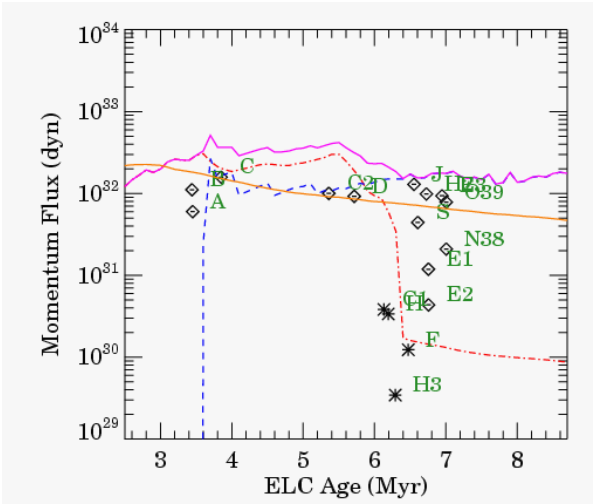

Figure 2. SSC outflow energetics quantities normalized to a 10^6 M_{sun} cluster (Kroupa IMF 0.1-100 M_{sun}, points), compared with Starburst99 predictions for stellar inputs (purple line) including contributions from stellar winds (red) and SNe (blue). The orange line represents the SSC's available radiative momentum flux.

References:

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