The origin of the NGC 3603 and 30 Dor (R136) starburst clusters

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NGC 3603 in our Galaxy and R136 (the center of the 30 Dor HII region) in the LMC are among the densest young star clusters known. They are resolved in HST and ground-based AO images, and their IMF is fully developed, down to sub-solar mass stars. The total mass of stars is of the order $10^5$ Msun. Thus they resemble small proto-globular clusters. Just how did they originate? Are they the result of a cloud cloud collision, followed by collapse of a finite sheet of dense gas? Rapid compression faster than a free-fall time seems to be a pre-requisite of their formation and compact nature. In this situation, competitive accretion in a deep potential well must play a role. We will discuss these issues, particularly the origin and survival of the these and similar starburst clusters, despite the tremendous feedback from tens to hundreds of massive stars (M>20 Msun).
• Origin of massive young clusters: fast set-up of initial conditions ➔
• Cloud-cloud collision (Fukui 2014)
• Shock compression ➔ dense sheet
• Sheet forms stars while collapsing
• Delayed collapse + final starburst (cf Burkert-Hartmann 2004 model)
• gas density: $10^4$ to $10^5$ Mo/pc$^3$
• Competitive hierarchical accretion, >50% SFE, grav. trapped HII region
SPH simulation of hierarchical cluster formation (sub-clusters in the process of „wet“ merging) (Bonnell, Bate, & Vine 2003)

Maybe the N2070/R136 cluster formed by merging of subclusters (cf. WFC3 obs. Sabbi et al. 2012)
[CII] cooling line (red) in the 30 Dor PDR
NGC3603 cluster (JHK)

The Galactic Starburst Region NGC 3603
NGC 3603 PDR
SOFIA [CII] 158mu data
NGC 3603  CO 3-2 map
ATLAS-Gal G23.21 clump: protocluster infall

redshifted absorption line 1.6 km/s wrt systemic vel.

SOFIA/GREAT 1.81 THz / 165 mu

NH$_3$ $3_{2+}$-$2_{2-}$
Using THz Ammonia Lines to probe infall

Interpretation of infall using optically thin emission lines is difficult, due to complicated radiative transfer and possible contributions from outflowing molecular gas.

Absorption measurements against a FIR continuum source are much more straightforward to interpret (Wyrowski 2015)

Infall (“collapse”) is the Holy Grail of star formation, and SOFIA THz absorption allows us to measure the gas infall rate.
Conclusions

• many, if not most, massive stars form in dense massive clusters, perhaps due to triggering effects
• Others forms in loose OB assoc, perhaps related to filament hubs
• In dense clusters: competitive hierarchical accretion in globally collapsing clouds, > 50% SFE, with grav. trapped HII regions
• In loose associations: turb core model of Tan & McKee applies
• At least two modes of massive SF