Star formation in the Local Group

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Summary

Our goal is to understand the physics of the accretion process, how solar-like stars grow in mass during the pre-main sequence (PMS) phase in different environments.

Spectroscopy shows us how the accretion process works in the solar neighbourhood (out to Orion), but not elsewhere. No spectroscopic observations of PMS stars in starburst clusters exist yet, not even in the Milky Way.

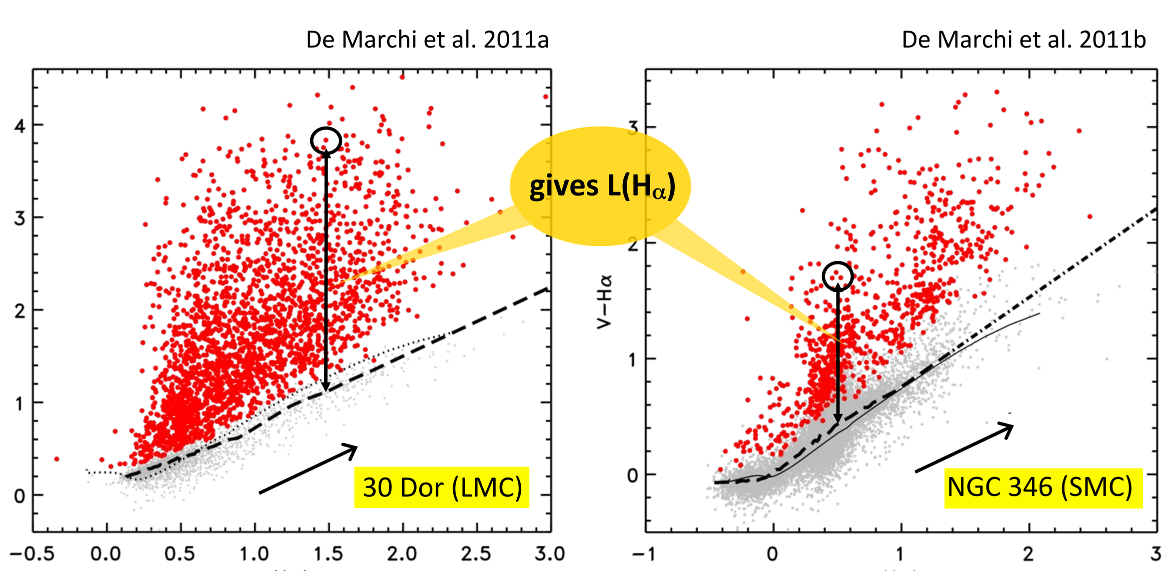
The Magellanic clouds are nearby and yet analogues to z≈2 galaxies, they probe physical conditions similar to those in place at the peak of star formation in the Universe (same metallicity, same ISM conditions).

A few hours of NIRSpec MSA spectroscopy will allow us to study hundreds of 0.5 – 3 $M_\odot$ PMS stars in dense star clusters in the Large and Small Magellanic clouds and in the Milky Way. This comparison will reveal how the star formation process depends on the physical conditions of the environment.

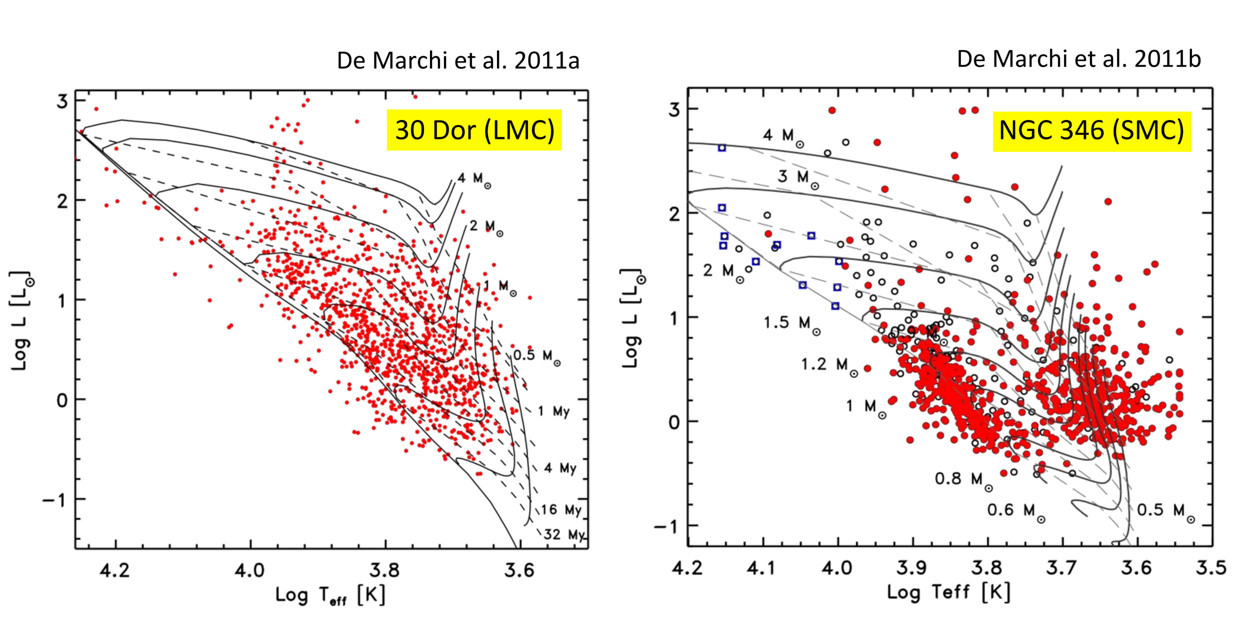
1. Actively accreting pre-main sequence stars

HST observations of massive young clusters in the local group have revealed that there are many PMS stars that continue to accrete matter for periods much longer than the few Myr typical of nearby associations of low total mass.

These PMS stars are discovered combining broad-band *(V, I)* and narrow-band *(Hα)* photometry and show strong Hα excess emission associated with the mass accretion process.

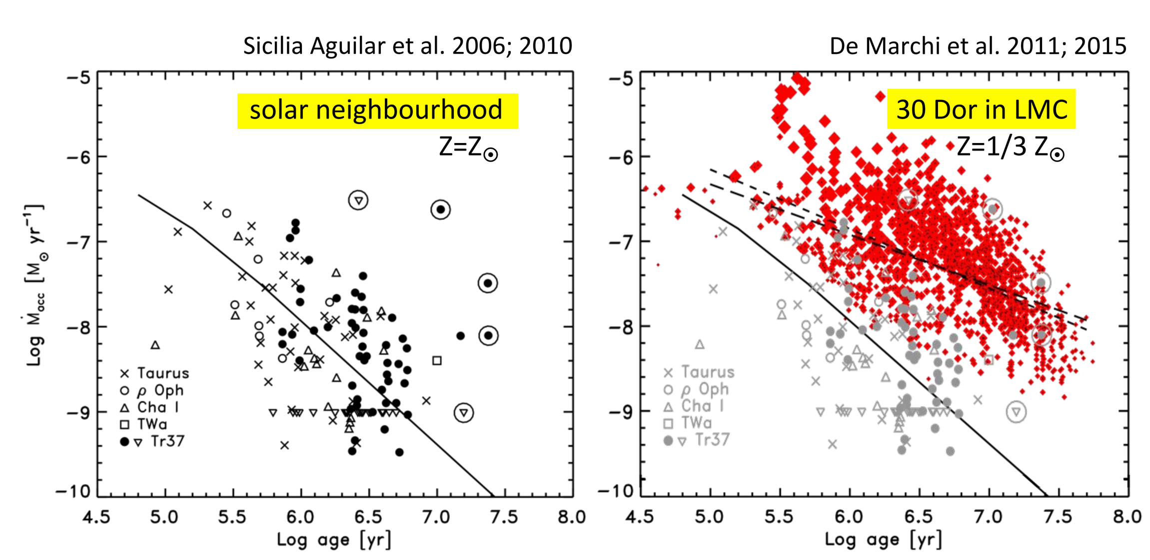


The stars are found in different regions of the HR diagram and in different regions of the cluster. This means that there is an intrinsic difference between these stars due to their age. The observations reveal that star formation has proceeded in these regions for at least ~30 Myr.



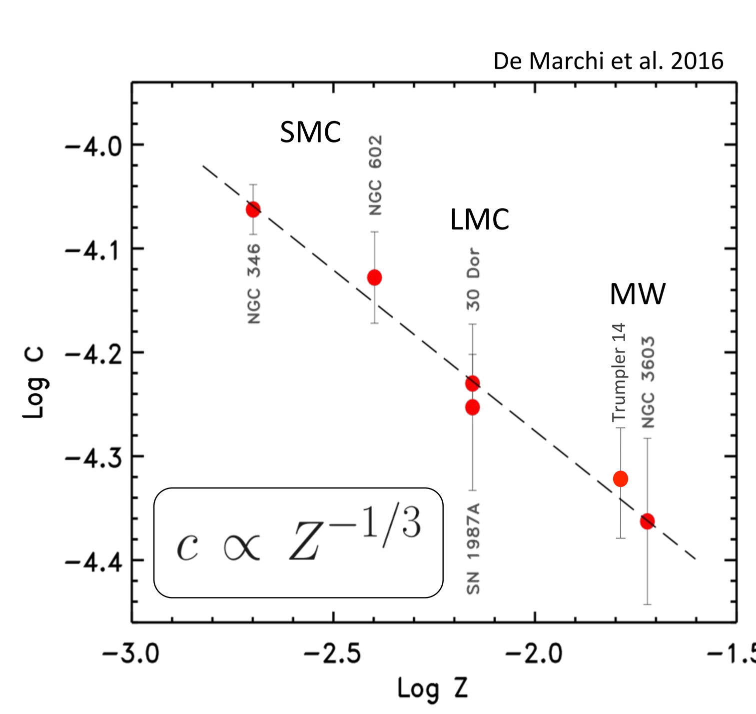
2. Mass accretion rate and metallicity

HST observations reveal thousands of PMS stars in Magellanic clouds clusters and show that in these low-metallicity environments stars accrete more and for a longer time than in nearby small Galactic star-forming regions. Circumstellar discs appear to live longer.



These preliminary results reveal that the mass accretion rate scales with $Z^{-1/3}$, the inverse of the cube root of the metallicity. This tantalising result must be understood in detail as it can have tremendous implications for the formation of stars and planets in the early Universe.

$$\log \dot{M}_{acc} \simeq \frac{3}{2}\log m - \frac{1}{2}\log t + \log c$$

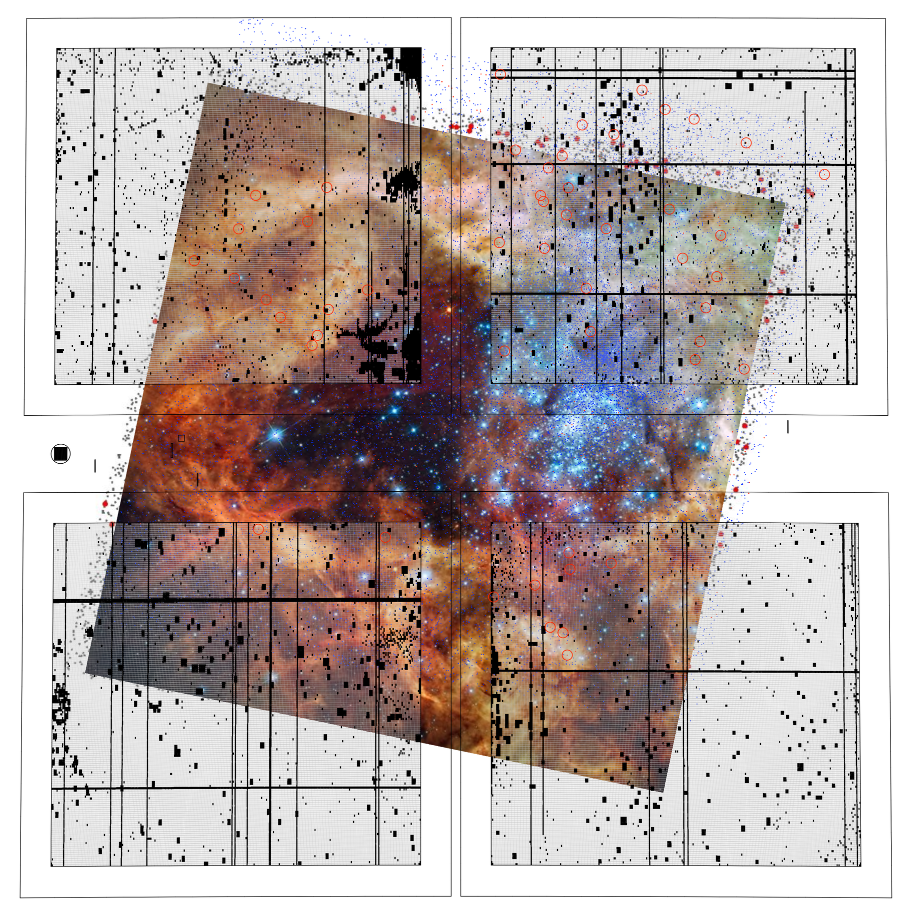


3. Multi-object spectroscopy with NIRSpec

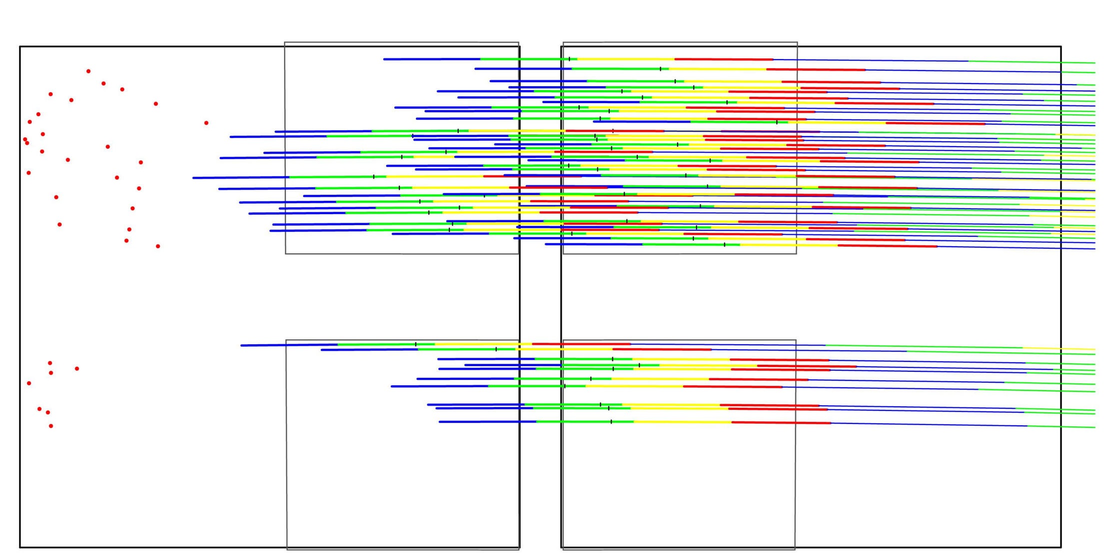
So far these results are based on photometric observations and we need medium-resolution spectroscopy to derive the properties of these older PMS stars.

The large field of view, exquisite spatial resolution, and the multiplexing capabilities of NIRSpec are uniquely suited to carry out this investigation, which no other instrument at present can achieve. Furthermore, the near infrared domain is ideal to minimise the effects of a high and variable extinction.

The massive clusters NGC 3603 in the Milky Way, 30 Dor in the LMC, and NGC 346 in the SMC are the ideal targets for this investigation. With several hundred PMS stars discovered with HST in each of them, regardless of the actual JWST orientation, there are always 50 – 100 objects that can be simultaneously placed inside the acceptance zone of a microshutter and have no other objects falling in the two neighbouring shutters.



With spectral resolution R=1000 and the G235M grating we will sample simultaneously three H recombination lines (Paα, Brβ, and Brγ). The luminosity of these lines provides a direct measure of the accretion luminosity, from which we will derive the mass accretion rate.



Spectroscopy will tell us much more about the physics of these objects. For instance, since Paα and Brβ have considerably different opacities, we can probe the density and temperature of the ionised material in different parts of the emitting region. Furthermore, the line profiles will reveal the kinematical properties of the infall that accompanies the accretion process.

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