FLAMES multi-object spectroscopy of low mass stars in the "twin" young clusters σ Ori and λ Ori

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ABSTRACT

Using FLAMES on VLT/UT2, we obtained spectra of 147 low-mass candidate members of the two young (~5 Myr) and coeval clusters σ Ori and λ Ori. We identified 65 *bona fide* cluster members in the former and 45 in the latter. We found three *bona fide* members of σ Ori that show severe Li depletion, implying nuclear ages greater than 10-15 Myr, much larger than the cluster average age. We also identified Classical T Tauri Stars (CTTSs) in the two clusters and measured their mass accretion rates. The fraction of CTTSs and the mass accretion rates in the σ Ori cluster are significantly larger than in λ Ori.

1. INTRODUCTION

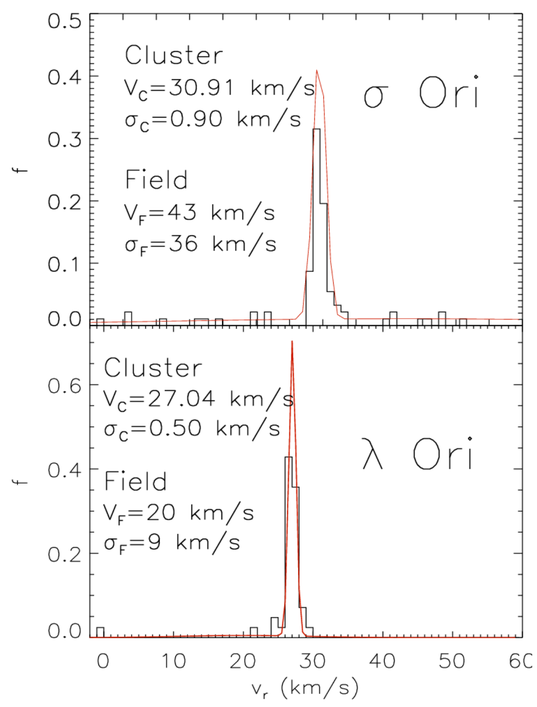
The timescale of star birth is one of the main open issues in the star formation theory. HR diagrams show a spread of $\geq 10^7$ years in individual clusters and associations, but the effect of various sources of errors are largely debated.
The determination of lithium abundances represents a secure method to derive ages of young low-mass stars, allowing us to verify the existence of age spreads inferred from HR diagrams.

The relationship between the mass accretion rate through the disk and the mass of the central star, age, and environment constitutes another critical issue. Recent surveys in Taurus and ρ Oph suggest a strong dependence of the mass accretion rate M_{acc} on the star mass M_{star} ($M_{acc} \propto M^2_{star}$) and a large dispersion at fixed mass. Further investigations on clusters of different ages and environmental conditions can help improving our comprehension of accretion disks physics.

σ Ori (4-5 Myr) and λ Ori (1-10 Myr) are 2 young clusters belonging to the Orion star forming region (d~400 pc). Both clusters are composed of about ten early-type stars, among which a central brightest star (σ Ori AB, O9.5 V and λ Ori, O8 III), and of about ~100 late-type stars. We observed 98 and 49 sources in σ Ori and λ Ori, respectively, using the FLAMES multi-object spectrograph on VLT/UT2, with the high-resolution (λ/Δλ=17,000) HR15N grating (647-679 nm). Cluster candidates are K and M stars (V=14-18), selected using optical, infrared and X-ray data from the literature.

2. MEMBERSHIP

Cluster members were identified using three independent criteria: radial velocity (RV) within 3 σ_c from the cluster average, the presence of Hα in emission, and Li pseudo-equivalent width (pEW) greater than 200 mÅ. The figure shows the observed RV distributions (black histogram), with overplotted (red line) the best fit obtained with the weighted sum of two gaussians, one for the cluster (V_C and σ_C) and the other for the field (V_F and σ_F).

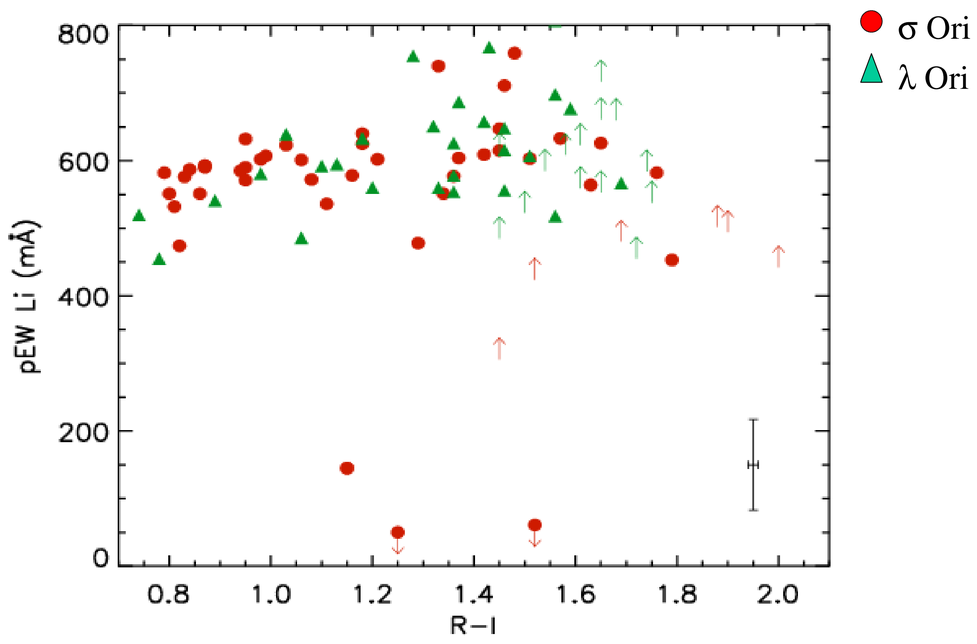


Results: In σ Ori we identified 65 members. For 62 of them, the three criteria provide coherent results. 3 stars are instead *bona fide* members for RV and Hα, but have Li pEWs below 200 mÅ. Membership for these stars is also supported by photometry and X-ray emission; most likely, they are member stars that have depleted their Li. In the λ Ori cluster we confirmed membership for 45 of the 49 candidates.

3. LITHIUM AND AGES

The Li test rests on the characteristic of stars to deplete their initial Li content during the early PMS contraction. It has been shown that the physics required to study Li depletion in fully convective stars has little uncertainty (Bildsten et al. 1997). Stars in the range ~0.1-0.4 $M_\odot$ start depleting Li after about 2 Myr and completely destroy it in ~20 Myr; the timescale of Li depletion depends on mass.

Results: The figure shows Li pEWs, corrected for veiling, as a function of R-I color. Most stars in both clusters have pEWs above 500 mÅ, corresponding to abundances close to the interstellar value.

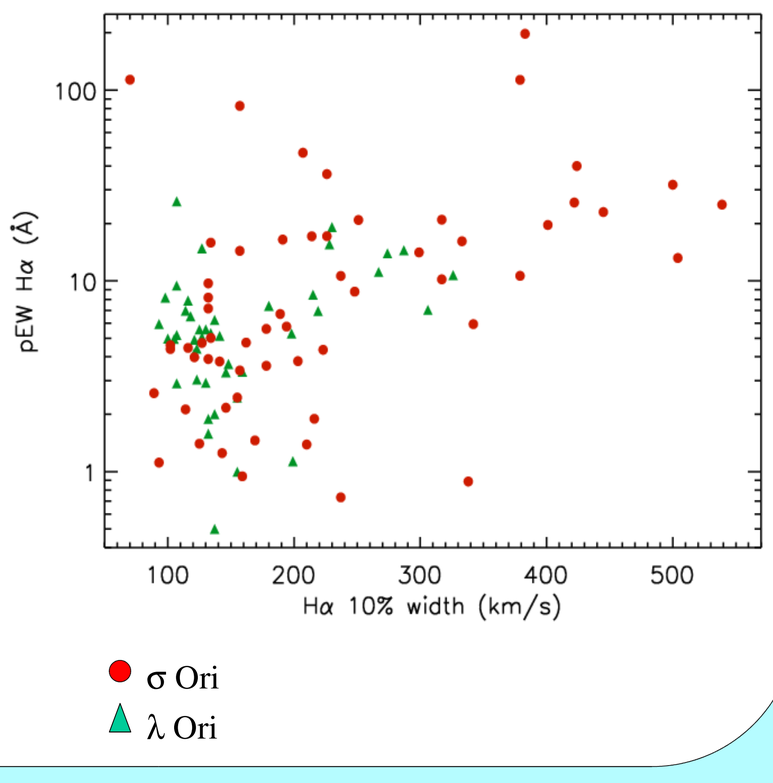


3 stars in the σ Ori cluster have pEW below 200 mÅ (A(Li)<0.0). Nuclear ages of these latter stars exceed 10-15 Myr and are in reasonable agreement with those derived from color-magnitude diagrams. This result proves the age dispersion suggested by color-magnitude diagrams and suggests that σ Ori formed more than 10 Myr ago.

4. ACCRETION DIAGNOSTICS

The figure shows Hα pEWs as a function of the Hα width at 10% of the maximum, from which we derived accretion rates using the relationship of Natta et al. (2004).

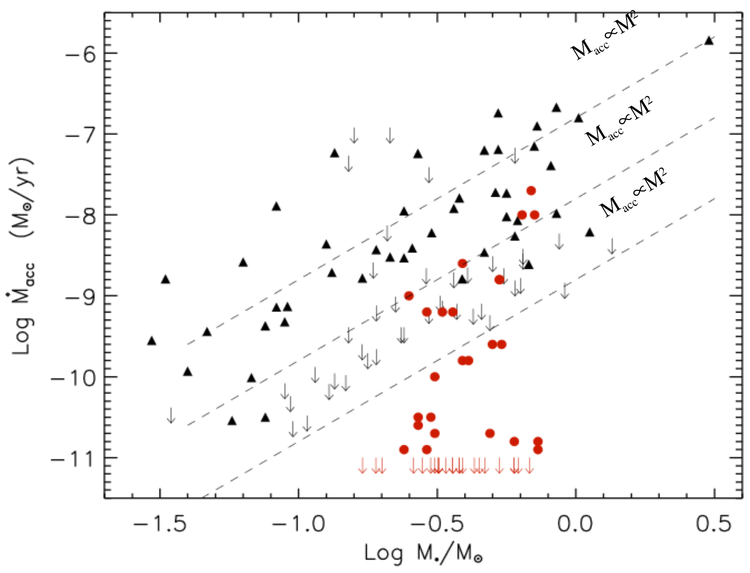
Results: the fraction of CTTSs is lower in σ Ori than in λ Ori (13% vs. 34 %). We exclude that this result is an effect of age or mass. As already hypothesized by Dolan & Mathieu (2002), we suggest that circumstellar disks might be photoevaporated due to the UV radiation emitted from the high-mass OB stars, before the supernova explosion 1 Myr ago.



5. MASS ACCRETION RATES

The figure shows the mass accretion rate vs. the mass of the star for σ Ori members (red symbols) and for class II members of the younger ρ Oph (black symbols, Natta et al. 2006, from Paβ).

Results: mass accretion rates of σ Ori members are on average lower than those of stars of the same mass in ρ Oph.



We suggest an age effect. The different sample selection criteria and the different methods employed to derive mass accretion rates, however, do not allow us to draw a firm conclusion.

6. REFERENCES

Bildsten, L., et al. 1997, ApJ, 482, 442
Dolan, C. J. & Mathieu R. D. 2002, AJ, 123, 387
Natta, A., Testi, L., Muzerolle, J., et al. 2004, A&A, 424, 603
Natta, A., Testi, L. & Randich, S. 2006, A&A, 452, 245