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Intracluster Age Gradients And Disk Longevities In Numerous MYStIX And SFiNCs Young Stellar Clusters

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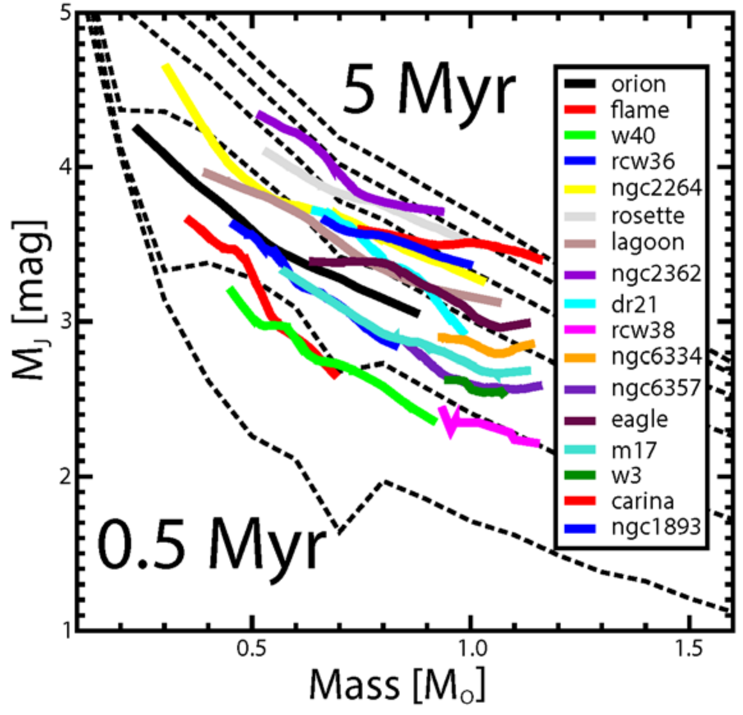
Data & Age_{JX} estimator

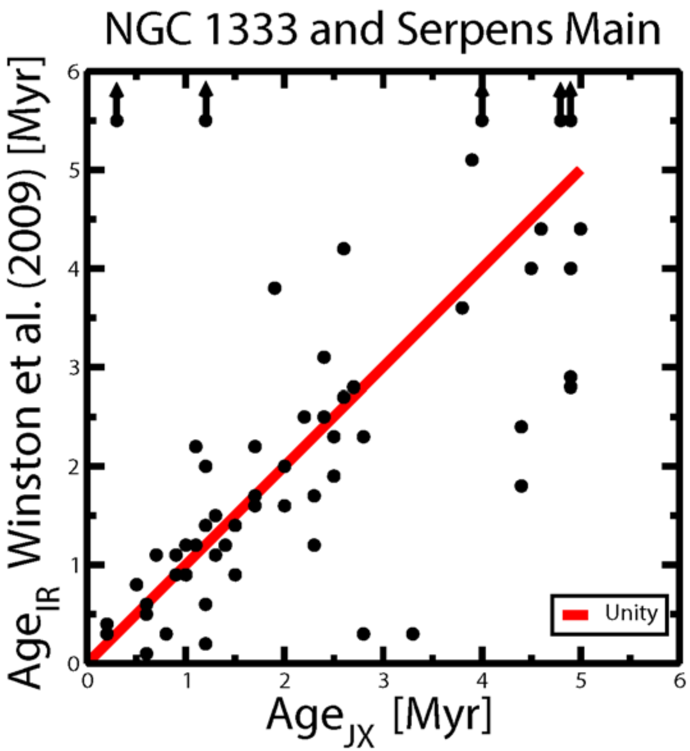
- SURVEYS: MYStIX (Feigelson et al. 2013 and references therein) and SFiNCs (Getman et al. 2017).
- Based on re-analyses of archival data from the Chandra X-ray Observatory, Spitzer Space Telescope, UKIRT and/or 2MASS.
- Characterize >40 young, nearby star forming regions.

- Age_{JX} is a PMS age estimator (Getman et al. 2014a).
- Based on X-ray and near-IR photometry.
- Calibrated to the X-ray Luminosity – Mass PMS relation (Telleschi et al. 2007) and to theoretical evolutionary tracks of Siess et al. (2000).



Age_{JX} estimator

- Age_{JX} estimates are in good agreement with stellar ages derived from near-IR spectroscopy + photometry (Winston et al. 2009).

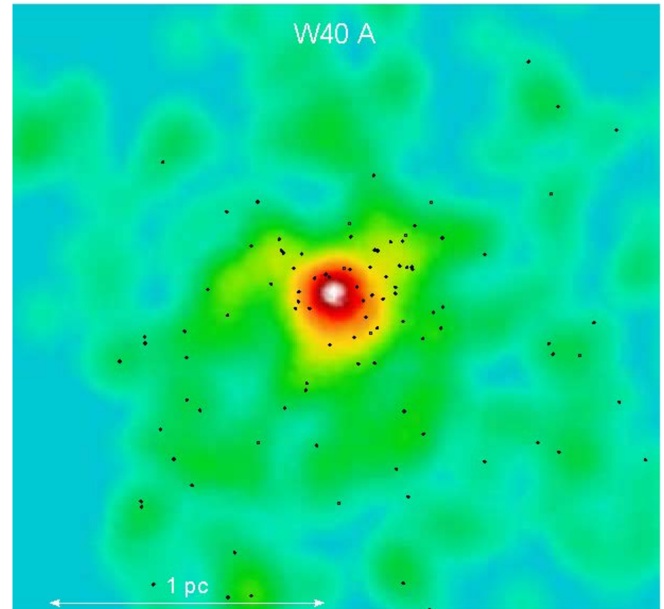


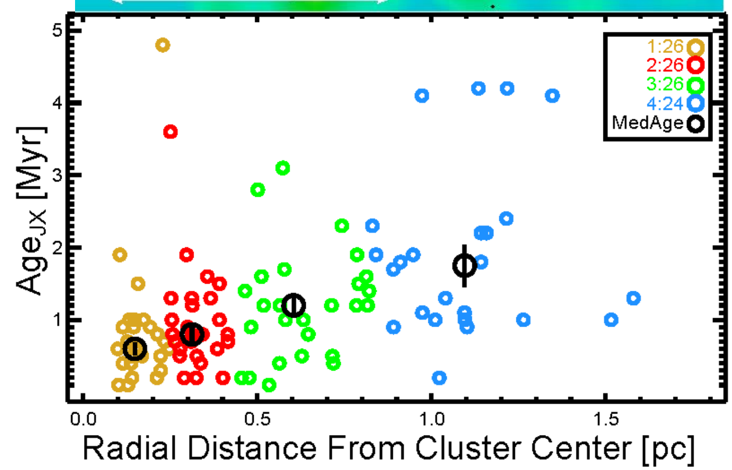
Intracluster Age Gradients (Getman et al. in prep)

- MYStIX+SFiNCs sub-sample of 19 clusters that:
- 1) have simple core-halo morphology;
- 2) are isolated;
- 3) have relatively high numbers of Age_{JX} stars.

- Many individual clusters show trends of increasing core->halo age.
- But statistical significance is generally low.

Example: Stellar surface density map of W40 (Age_{JX} stars are black points):

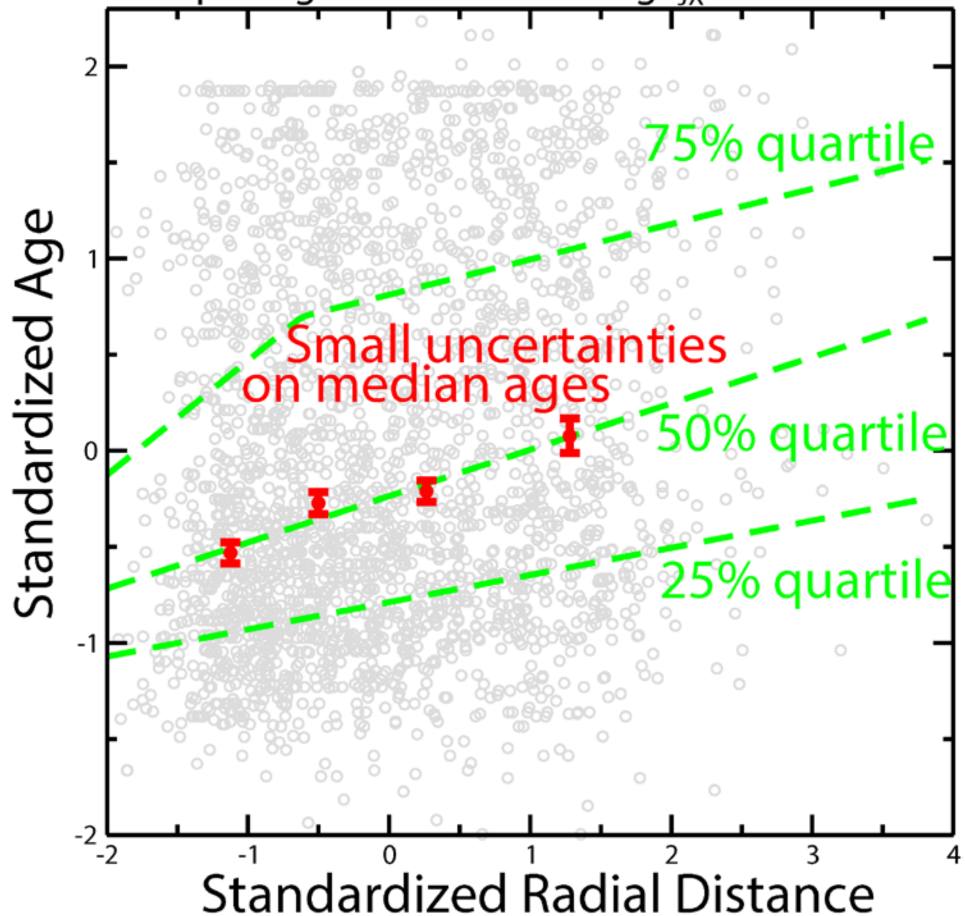




Intracluster Age Gradients (Getman et al. in prep)

- To reduce statistical uncertainties the clusters are merged together.
- Utilizing standardized age and radial distance variables:
  $x_{i,stn} = (x_i - \mu_{cluster})/\sigma_{cluster}$
- Now, the core-halo age gradient is statistically significant at over 5-sigma level.
- The gradients can be explained by the theoretical model of Vazquez-Semadeni et al. (2017).

Merged sample of 19 MYStIX+SFiNCs clusters comprising 2487 YSOs with Age_{JX}



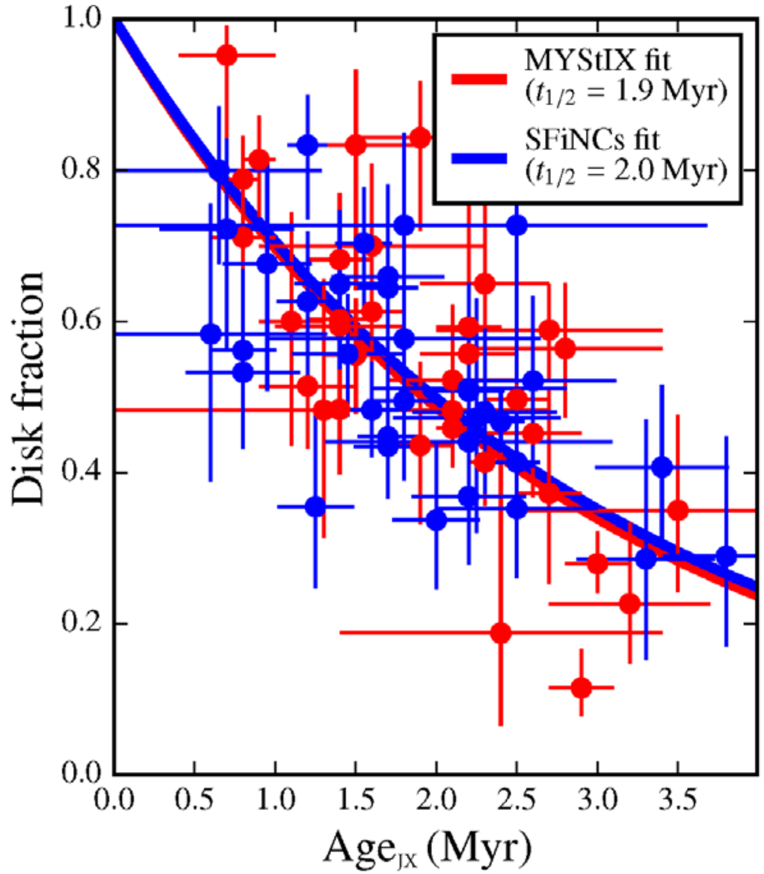
Disk Longevities (Richert et al. in prep)

- For each cluster:
1. NIR+IRAC SED-based disk classification;
2. YSO sub-samples with similar mass distributions for disky and diskless.

- The inferred disk fractions and median Age_{JX} are consistent with an exponential IRAC disk half-life of $t_{1/2} \approx 2$Myr.

- The similarity between the MYStIX+SFiNCs IRAC half-lives and those of Mamajek (2009; $t_{1/2} \approx 1.7$Myr), Fedele et al. (2010; $t_{1/2} \approx 2.1$Myr), and Ribas et al. (2014; $t_{1/2} \approx 1.6$-1.9Myr) is surprising considering numerous differing factors (YSO data, cluster samples, age methods, disk classifications, mass sensitivities, and so on).

69 MYStIX+SFiNCs young (≤4 Myr) stellar clusters



Intracluster Age Gradients And Disk Longevities In Numerous MYStIX And SFiNCs Young Stellar Clusters

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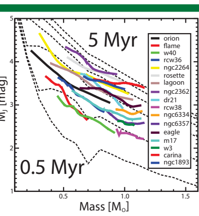
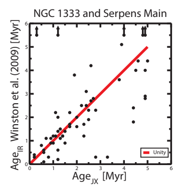
ABSTRACT. This study is based on YSO samples from the MYStIX and SFiNCs surveys, and a new estimator of pre-main sequence stellar ages (Age_{JX}), derived from X-ray and near-IR photometric data. We present two main results here. First, the discovery of core-halo age gradients (with younger cores and older halos) in numerous morphologically simple, isolated, and relatively rich stellar clusters. The observed spatio-age gradients can be explained within the framework of the global hierarchical collapse model. Second, the MYStIX+SFiNCs cluster surveys provide the largest cluster dataset to date to study circumstellar disk longevity in young (≤4 Myr) clusters. By imposing similar stellar mass sensitivity limits for disky and diskless YSOs and assuming disk fraction of 100% at the zero age, we estimate an exponential disk half-life of 2 Myr (based on Age_{JX} scale). This value agrees closely with the results of a few previous studies.

SURVEYS. MYStIX (Feigelson et al. 2013 and references therein) and SFiNCs (Getman et al. 2017) projects characterize >40 young star forming regions at distances <4 kpc, based on re-analyses of archival data from the Chandra X-ray Observatory, Spitzer Space Telescope, UKIRT, and 2MASS.

CONCEPT OF AGEJX. Our age method (Age_{JX}; Getman et al. 2014a) employs NIR and X-ray photometry. Stellar masses are derived from absorption-corrected X-ray luminosities using the Lx-Mass relation from young stars in Taurus. J-band magnitudes corrected for absorption and distance are compared to the mass-dependent PMS evolutionary models of Siess et al. (2000) to estimate ages.

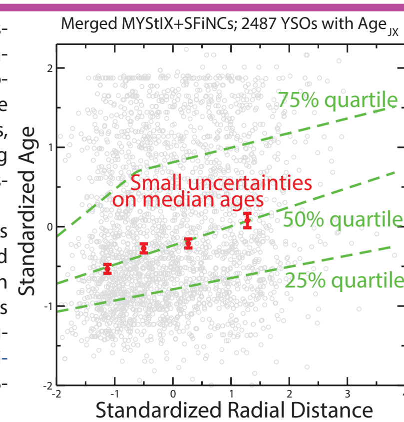


Comparison of ages for indivdual stars in the nearby NGC 1333 and Serpens Main SFRs: individual Age_{JX} estimates are in good agreement with stellar ages derived from near-IR spectroscopy + photometry (Winston et al. 2009).



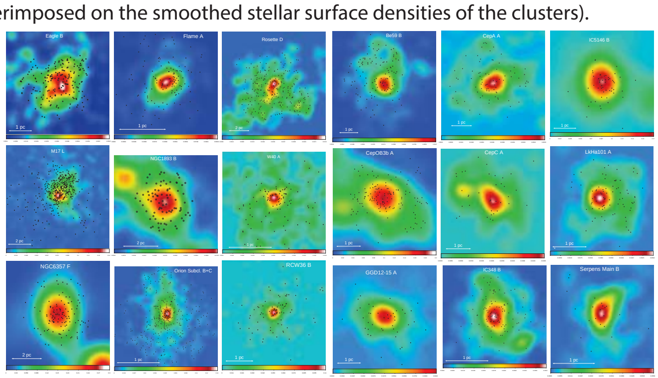
AGE GRADIENTS. To reduce statistical uncertainties on the age variations, the clusters are merged together. Since they span wide ranges of ages and spatial extends, the merger is performed using standardized age and radial distance variables:

$x_{i,stn} = (x_i - \langle x \rangle_{cluster})/\sigma_{cluster}$. This analysis shows that the observed core-halo age gradient (with younger cores and older halos) is statistically significant at over 5-sigma level. Median spatio-age gradient among all the considered MYStIX+SFiNCs clusters is 0.9 Myr/pc.



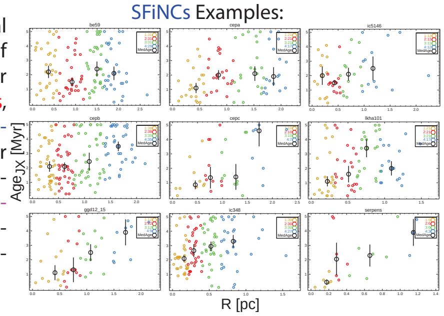
The observed gradient can be explained by the model of Vazquez-Semadeni et al. (2017): a large cloud globally gravitationally contracts, with multiple filaments (harboring non-coeval stellar groups) falling towards the center of gravitational potential, where the main cluster forms. Due to their higher velocity dispersions the in-falling older stars tend to appear further from the cluster center.

AGE GRADIENTS (Getman et al. in prep). Getman et al. (2014b) discovered core-halo age gradients in ONC and NGC 2024. Here we consider a larger MYStIX+SFiNCs sub-sample of clusters that: 1) have simple core-halo morphology; 2) are isolated; 3) have relatively high numbers of Age_{JX} stars (black points superimposed on the smoothed stellar surface densities of the clusters).

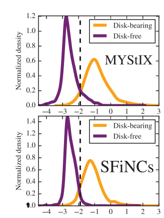


Age_{JX} as a function of radial distance from the centers of the clusters shows that for many individual clusters, there are trends of increasing age from the cluster center toward the cluster periphery; however, the statistical significance of the observed age variations is generally low.

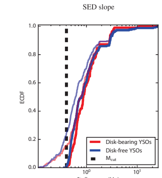
SFiNCs Examples:



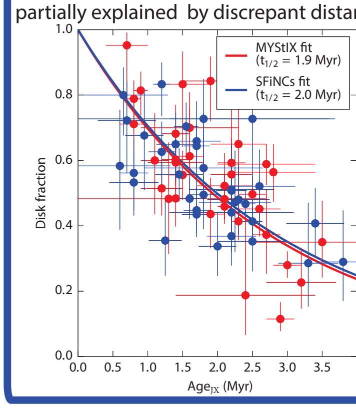
DISK LONGEVITIES (Richert et al. in prep). Separation of the MYStIX and SFiNCs YSOs into disky and diskless stars was done using two classification schemes: 1) the original NIR+IRAC SED-based classifications of Povich et al. (2013; MYStIX) and Getman et al. (2017; SFiNCs); 2) classification based on apparent IRAC SED slope, adopting a critical value of α_{IRAC}=-1.9 for separating disky and diskless.

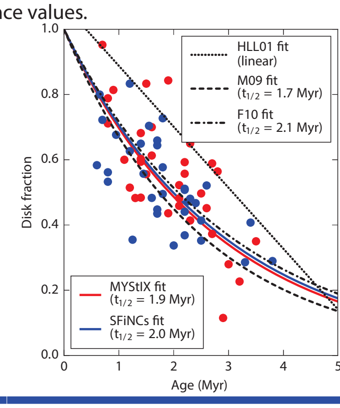


Stellar masses are estimated using near-IR photometry. For each cluster: 1) the mass distributions of disky and diskless populations are compared; 2) the lowest-mass YSOs are iteratively removed to achieve similar mass distributions and mass sensitivities for disky and diskless YSOs; 3) disk fractions are then calculated.



DISK LONGEVITIES. The inferred disk fractions and median AgeJX estimates for 69 MYStIX+SFiNCs clusters are consistent with an exponential disk half-life of ~2 Myr (Richert et al. in prep.). Our cluster sample exceeds previous cluster samples by more than a factor of three. The similarity between the MYStIX+SFiNCs IRAC disk half-lives and those derived in Mamajek (2009), Fedele et al. (2010), and Ribas et al. (2014) is surprising considering numerous differing factors (YSO data, cluster samples, age methods, disk classifications, mass sensitivities, and so on). With regards to the study of Bell et al. (2013), the MYStIX+SFiNCs and Bell et al. cluster ages are farily consistent for 4 out of 6 clusters in common. The age inconsistency for Cep OB3b and IC 348 (~2-3 Myr in SFiNCs versus ~6 Myr in Bell et al.) can be partially explained by discrepant distance values.





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