Filling The Missing Link In Stellar Magnetic Activity Evolution

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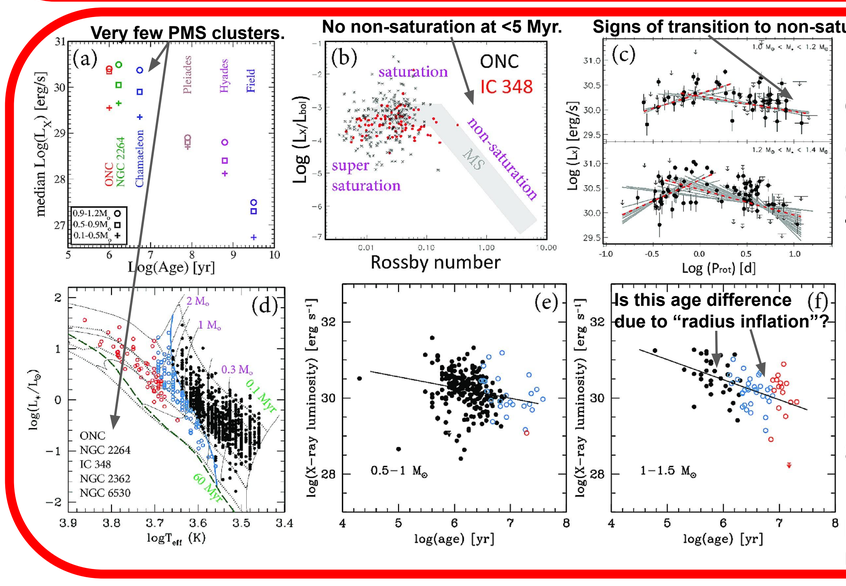
"Missing Link Clusters" is a Chandra Large Project to examine rich open stellar clusters aged 5-30 Myr that form a "missing link" in our understanding of evolution of pre-main-sequence (PMS) stellar activity. Half of 12 proposed missing link clusters within 2 kpc distance have already been observed by Chandra. Here, we report on the characterization of the cluster membership, distances and ages, stellar X-ray and bolometric luminosities, and stellar masses employing Gaia, 2MASS, Spitzer, WISE and various ground-based optical-infrared photometric data. The goal is to derive mass-stratified activity-age-rotation relations in early stellar evolution for the combined sample of ~6000 "missing link" stars and >30000 younger (<5 Myr) stars from our published MYStIX and SFiNCs projects.

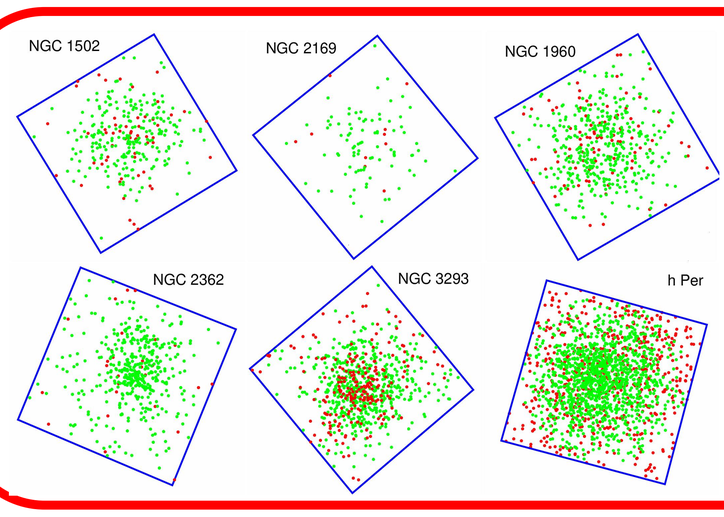


By t~30Myr most >0.6M_O PMS stars develop radiative cores, which will change magnetic dynamo processes and probably X-ray emission [7,8]. The dependence of activity on stellar mass and rotation is uncertain [2]. Rich, homogeneous "Missing Link"+MYStIX+SFiNCs datasets will improve our understanding of PMS activity-age-rotation relation.

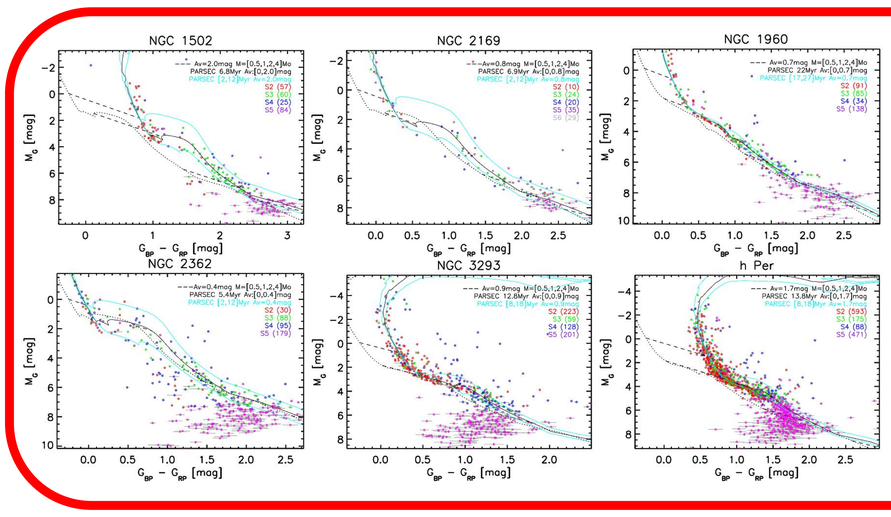
Panels (a), (b), (c), (d,e,f) are from [8], [1], [2], and [7] respectively.

Chandra-selected cluster members reveal Gaia **proper-motion (P-M) locii**, identifying non-Chandra young stars.

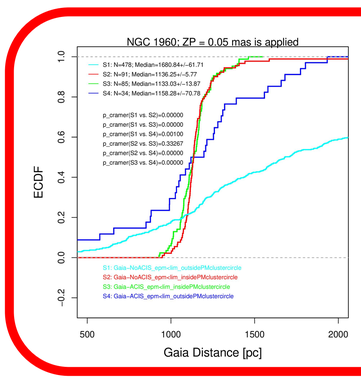
Figure panels show P-M diagrams for all Gaia (left) and Chandra-selected sources (right) across 6 open clusters.



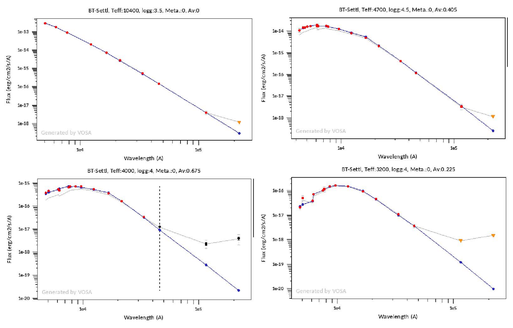
ACIS Extract [5] characterizes >7000 X-ray point sources across **6 open clusters**. We identify **3000** ACIS (green) and **1000** non-ACIS (red) **young sars** based on their Gaia and Chandra properties.



Cluster average extinction and age$_1$ are from Gaia color-magnitude diagrams using **PARSEC** PMS **models** [4] with a "non-magnetic" correction for radius inflation.

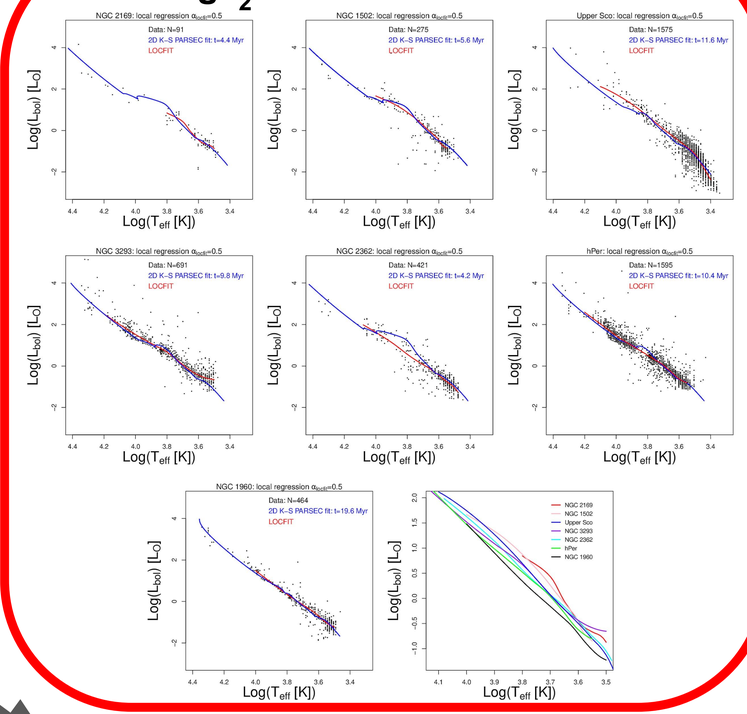


Median cluster distances are estimated using young stars with accurate Gaia parallaxes.

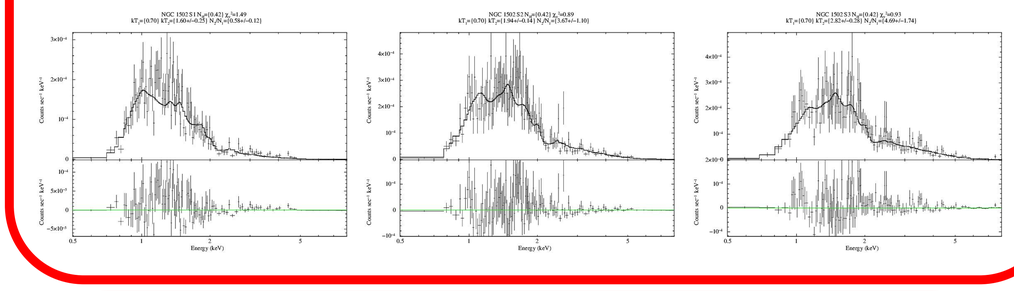


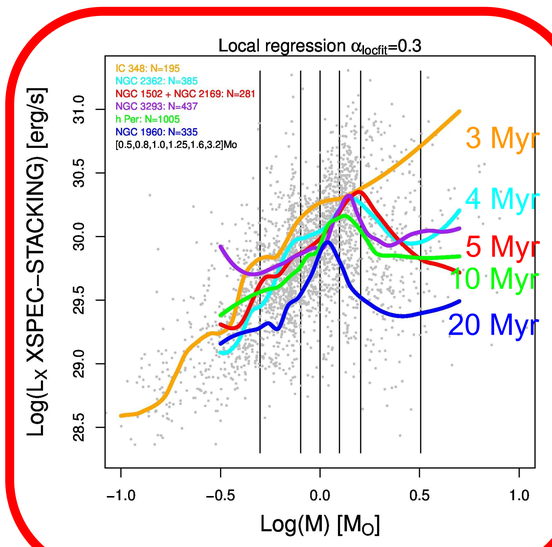
Optical-infrared stellar photometry and the VO SED Analyzer [3] give **stellar bolometric luminosities and effective temperatures**.

Cluster **age**$_2$ & **stellar masses** from HRD.



Stellar X-ray luminosities are derived using 2 methods: 1) source spectral stacking in three different X-ray median energy bands, followed by simulations and 2) the XPHOT procedure [6].

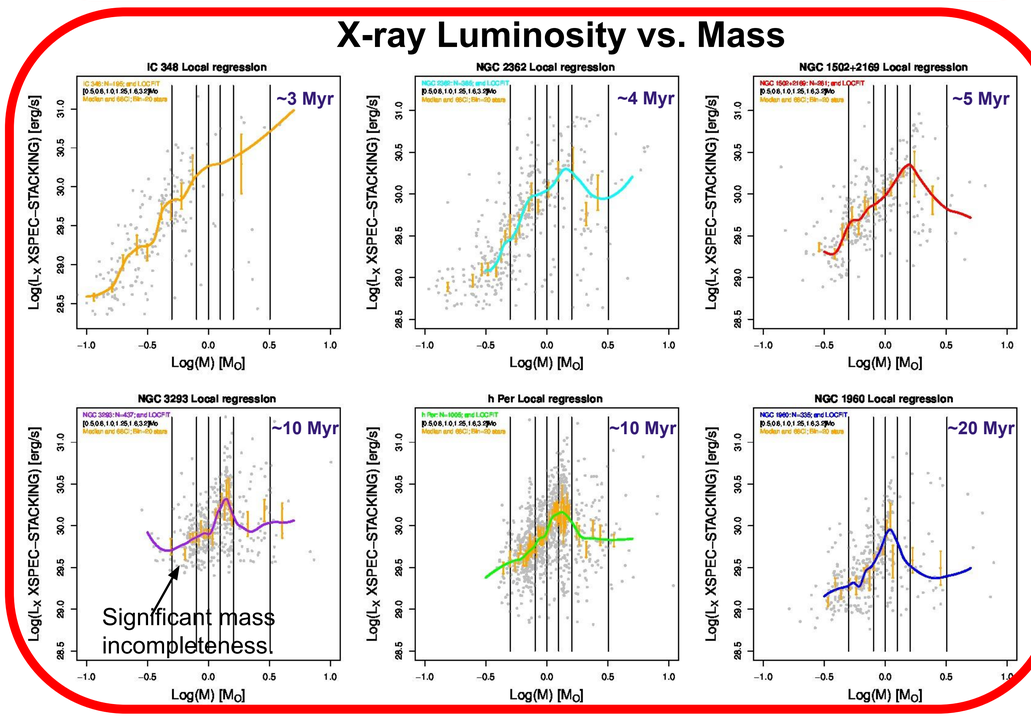




Preliminary results show: 1) **PMS X-ray luminosities systematically decrease with time for >0.5Mo stars**, 2) **X-ray luminosity turnover points shift.** Both effects may be due to the combination of stellar contractions on Hayashi tracks and transitions from Hayashi to Henyey tracks.

Next steps: new Chandra data for several more 5-30 Myr old open clusters are coming. Data for many young (<5Myr) rich MYStIX/SFiNCs clusters will be incorporated. Statistical survival analysis will be applied. ZTF rotation periods are tested; dependence of X-ray luminosity on rotation will be examined.

X-ray Luminosity vs. Mass



[1] Alexander & Preibisch 2012, A&A, 539, A64
[2] Argiroffi et al. 2016, A&A, 589, A113
[3] Bayo et al. 2008, A&A, 492, A277
[4] Bressan et al. 2012, MNRAS, 427, 127
[5] Broos et al. 2010, ApJS, 209, 32
[6] Getman et al. 2010, ApJ, 708, 1760
[7] Gregory et al. 2016, MNRAS, 457, 3836
[8] Preibisch & Feigelson 2005, ApJS, 160, 390