Where is Sc andium?

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Sc
Scandium

A SPECTROSCOPIC PROBE OF DIFFUSION IN AmFm STARS

KEEP IN TOUCH WITH ME!

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Why does scandium behave so differently in AmFm stars — and how does this behaviour evolve with age? Atomic diffusion results from a complex interplay between gravitational settling, radiative acceleration, and mixing, yet observational constraints remain sparse, particularly between 100 and 500 Myr. We target this poorly explored age range using AmFm stars in young open clusters. From high-resolution spectra, we derive atmospheric parameters, chemical abundances, and radial velocities, with particular emphasis on scandium. By tracing Sc across cluster ages, we aim to test diffusion models and constrain the physical processes shaping chemical peculiarities in intermediate-mass stars.

AmFm STARS

AmFm (CP1) stars are non-magnetic A- and early F-type stars whose atmospheres show a characteristic signature of atomic diffusion: Ca and Sc are depleted, while iron-peak and heavier elements are typically enhanced. This abundance pattern results from the competition between gravitational settling and radiative acceleration and is further modified by other transport processes (like convection, turbulent mixing or mass loss). Scandium is particularly sensitive to these processes, making it a powerful tracer of the physical origin and evolution of the AmFm phenomenon.

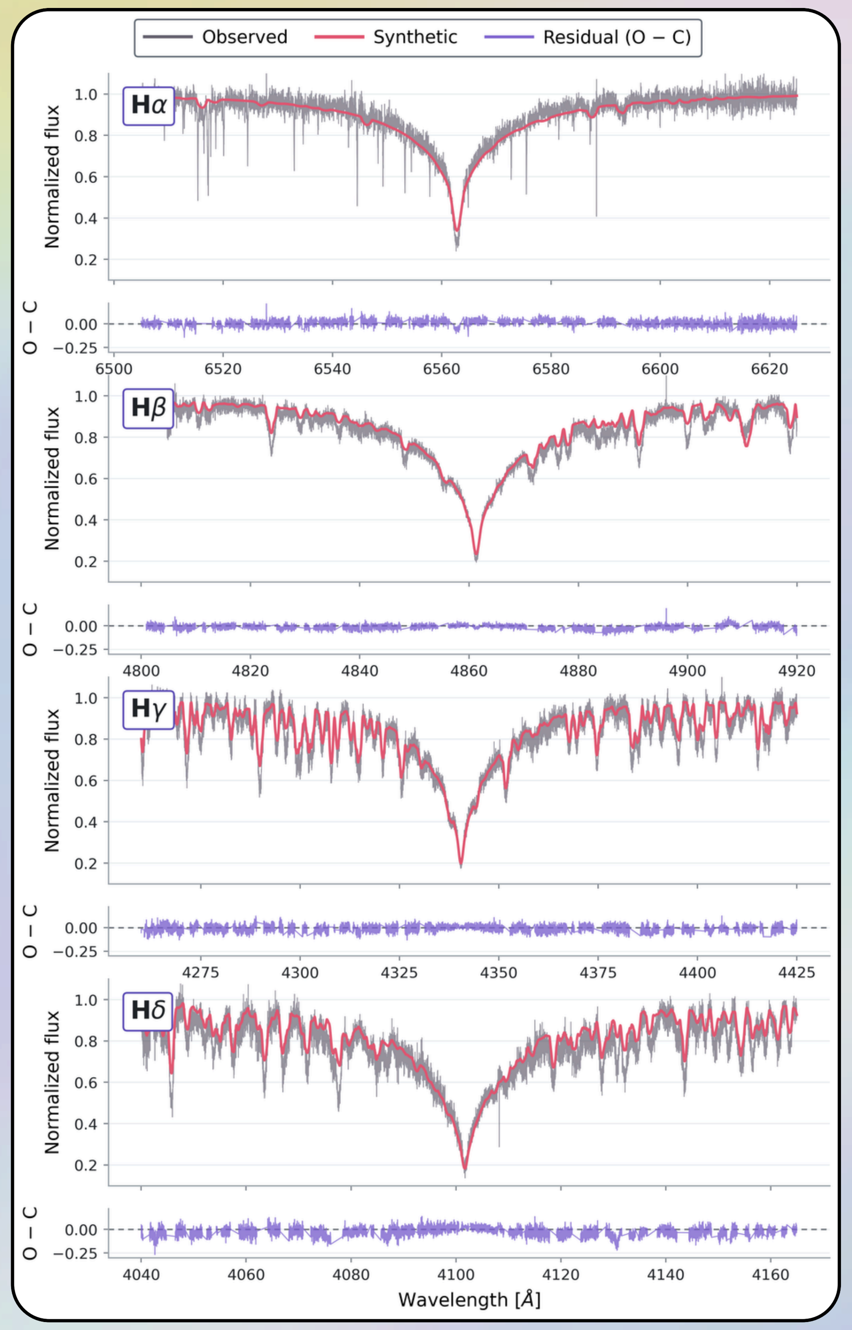
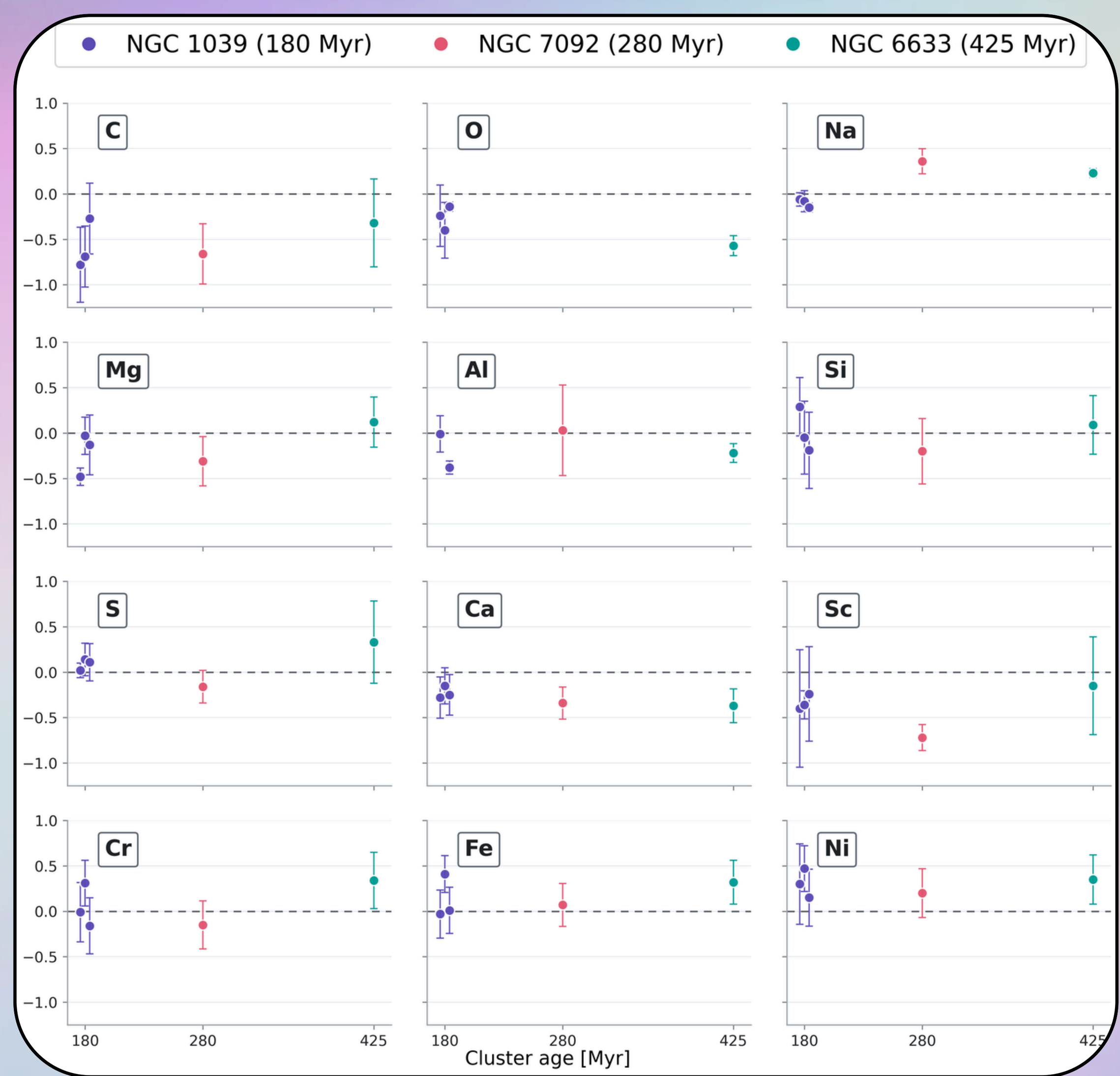


Figure 1. Atmospheric-parameter determination for TYC2843-2005-1 (NGC 1039): $T_{\rm eff}$ = 7650 ± 200 K, log*g* = 4.0 (fixed), *v*sin*i* = 43 ± 4 km s^{-1}

Figure 2. Preliminary abundance patterns for five candidate AmFm stars in three young open clusters.



OPEN CLUSTERS

Open clusters provide a unique time sequence for tracing the emergence of AmFm chemical peculiarities. Their members share approximately the same age and initial chemical composition, allowing abundance differences to be linked more directly to stellar evolution than in field-star samples.

Our sample spans 13 young clusters and stellar groups, with ages from approximately 10 to 447 Myr, providing particularly dense coverage of the previously under-sampled 100–500 Myr interval. This age baseline allows us to search for evolutionary changes in Sc and other elemental abundances and to compare them directly with diffusion models.

OBSERVATIONS

Our spectroscopic sample includes 29 young AmFm candidates covering the still poorly explored 100–500 Myr age range.

Most of the spectra were obtained with HARPS-N at TNG during dedicated observing campaigns, with a smaller contribution from CAOS observations carried out at INAF–OACT. The dataset provides high-resolution, high-S/N spectra suitable for a detailed abundance analysis, while repeated observations also allow us to measure radial velocities and search for possible spectroscopic binaries.

ATMOSPHERIC PARAMETERS

Atmospheric parameters are derived through a homogeneous comparison of observed and synthetic spectra computed with ATLAS9 model atmospheres and SYNTHE.

$T_{\rm eff}$ is constrained primarily from Balmer-line profiles (Fig.1) and independently checked using Fe I excitation equilibrium. The microturbulent velocity ξ is adjusted until the derived Fe abundance shows no dependence on line strength, while *v*sin*i* is determined from metal-line profiles.

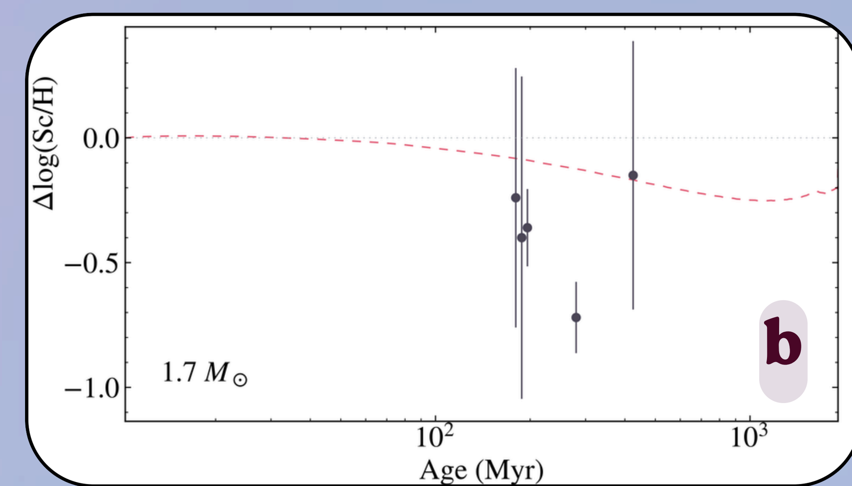
For stars hotter than approximately 8000 K, Balmer-line wings provide an important constraint on logg; for cooler stars, the Fe I/Fe II ionisation balance is used as the primary gravity diagnostic.

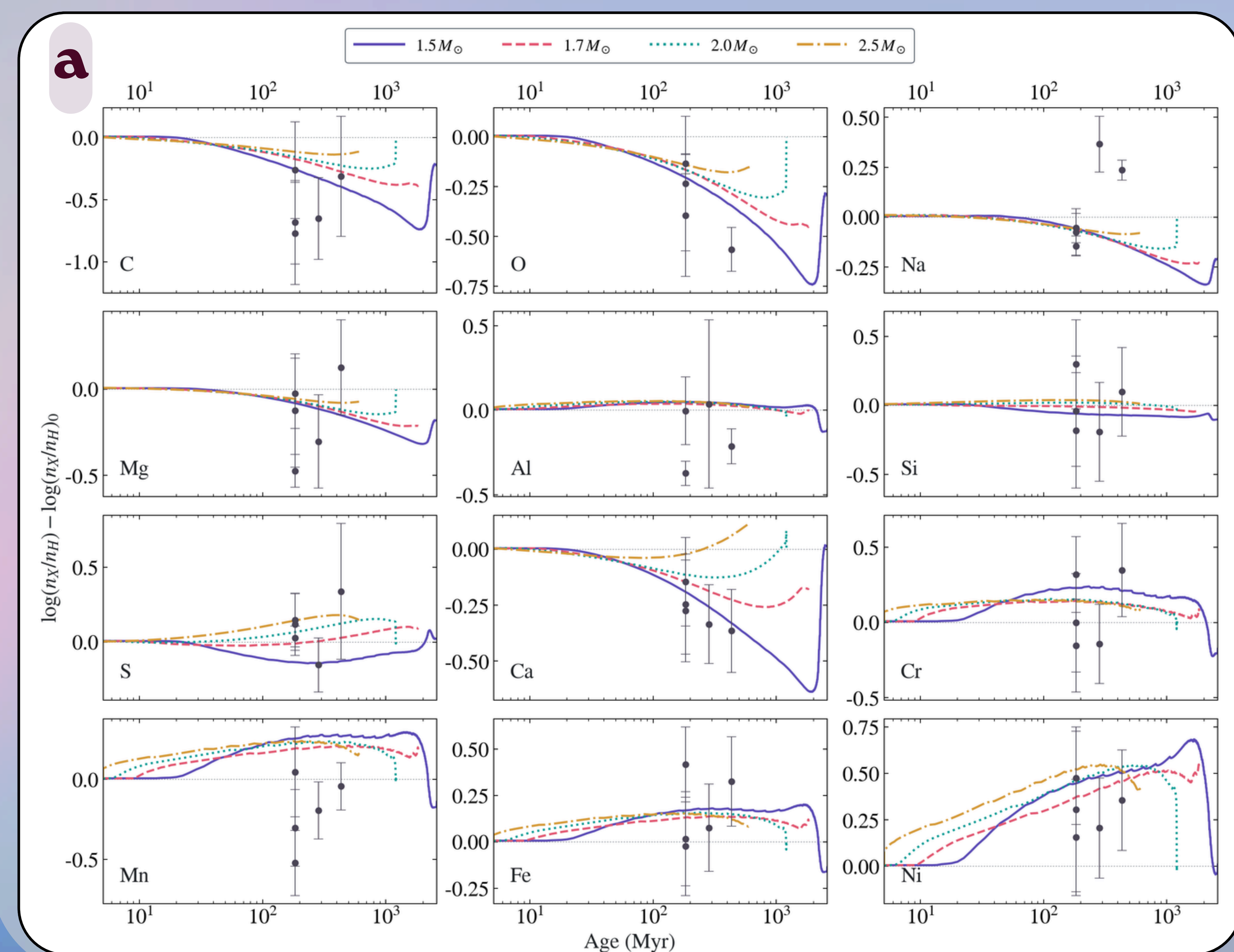
ABUNDANCES

Chemical abundances are derived by direct comparison of observed and synthetic line profiles, using the same analysis procedure throughout the sample.

Our preliminary analysis currently includes five stars in three open clusters. The resulting abundance patterns (Fig.2) allow us to ask not only how chemically peculiar an AmFm star is, but also which elements evolve together — and which do not.

Figure 3. Time-dependent diffusion models of abundance evolution in AmFm star atmospheres: (a) 12 elements for 1.5, 1.7, 2.0, and 2.5 $M_\odot$, and (b) scandium for 1.7 $M_\odot$, with mixing extending down to the Z-bump and computed without mass loss.





CHEMICAL EVOLUTION

Rather than treating the AmFm abundance pattern as static, we trace its evolution with stellar age.

We compare our observations with evolutionary diffusion calculations computed with the Toulouse–Geneva Evolution Code (TGEC) for 1.5, 1.7, 2.0, and 2.5 $M_\odot$ using the turbulent-mixing prescription of Hui-Bon-Hoa et al. (2024) and assuming no mass loss.

The current comparison includes 13 elements: C, O, Na, Mg, Al, Si, S, Ca, Sc, Cr, Mn, Fe, and Ni. Figure 3 compares our preliminary abundance patterns with models including turbulent mixing extending down to the Z-bump.