Exploiting the lithium abundances in iDR5

Elena Franciosini

INAF – Osservatorio Astrofisico di Arcetri
Lithium in iDR5

- Gaia-ESO iDR5 = largest database to date of homogeneous Li abundances
- $\sim 23,000$ stars with Li measures or upper limits (abundances and/or EW)
  - $\sim 48\%$ in 15 young open clusters ($< 100$ Myr)
  - $\sim 25\%$ in 23 old open clusters (up to 7 Gyr)
  - $\sim 5\%$ in 14 globular clusters
  - $\sim 22\%$ field stars (Corot, Kepler2, Bulge, MW)

$\Rightarrow$ unprecedented view of Li in our galaxy
Inhomogeneity problems in iDR4 - I

Two different measure methods:
- spectral synthesis with GES atmospheric models
- EWs + Curves of Growth (COGs) – BUT
  - No available COGs covering the entire GES parameter range ⇒ two sets:
    - Soderblom et al. (1993) for $T_{\text{eff}} = 4000 - 6500$ K
    - Palla et al. (2007) for $T_{\text{eff}} \leq 4000$ K
  - valid only for dwarfs, not appropriate for giants
  - inconsistent derivation ⇒ discontinuity problems around 4000 K
  - different model atmospheres from GES

⇒ new set of homogeneous COGs needed
Inhomogeneity problems in iDR4 - II

Inconsistent measures of Li EW in M-type stars

- FGK stars: Li + Fe I blend, can be deblended in UVES or corrected in Giraffe
- M stars:
  - molecular bands $\Rightarrow$ depressed pseudo-continuum, difficult to define
  - additional components severely blended with Li

Only reasonable measure = pseudo-EW integrated within interval

Possible inconsistencies between measure and COGs
Inhomogeneity problems: solution

- Guidelines on Li measures ⇒ prescriptions for M-type stars:
  - positioning of pseudo-continuum
  - integration interval (depending on rotation)
  - interval consistent with Li width at higher temperatures

- New COGs from grid by Guiglion et al. (2016), consistent with GES
  - $3000 \leq T_{\text{eff}} \leq 7500$ K, $1 \leq \log g \leq 5$, $-2.5 \leq [\text{Fe}/\text{H}] \leq +0.5$ dex
  - $-1.0 \leq A(\text{Li}) \leq +3.6$ dex
  - FGK COGs: $T_{\text{eff}} \geq 4000$ K, Li-only + Fe corrections, UVES+Giraffe
  - M COGs: $T_{\text{eff}} \leq 4500$ K, following guidelines, Giraffe only, vrot dependence

(see http://ges.ast.cam.ac.uk/GESwiki/GeSDR5/#Lithium_Curves_of_Growth)
Comparison of FGK and M COGs
Why lithium?

Lithium measures are useful for a variety of studies, e.g.:
- membership in young clusters
- age-dating of young clusters
- PMS evolution
- (extra-)mixing in old, solar-type stars
- Li-planet connection
- super-Li rich giants
- globular cluster formation
- Galactic evolution
Lithium in open clusters

- Li in open clusters: important tool to probe stellar structure and test evolutionary models
  - In low-mass stars ($< 1.2 M_\odot$) surface Li is depleted by mixing processes (convection, ...) at a rate depending on mass

- Standard models fail to reproduce all observations
  - Additional factors may affect Li depletion: e.g. rotation, magnetic activity and spots, inflated radii

- GES provides large sample of stars in several open clusters of different age and metallicity $\Rightarrow$ allows detailed investigation of these issues
Radius inflation in Gamma Vel

- Standard models cannot reproduce both CMD and Li depletion pattern in Gamma Vel at same age (Jeffries et al. 2017)
- Simple model: 10% radius inflation + polytropic structure ⇒ corrections to existing models

(Jeffries et al. 2017)
Spotted models

- Effect of spots at different ages (Gamma Vel, NGC 2547, NGC 2451 B, NGC 2516) using PISA models (Franciosini, Tognelli et al., in prep.)
- Spots incorporated in evolutionary code (see Somers & Pinsonneault 2015)
New prospects in iDR5

- Additional PMS clusters in iDR5 allow further comparisons and may provide additional constraints on models
- Example: \textit{lambda Ori} (7-10 Myr)
Li-rotation correlation

- Higher Li abundance in rapid rotators with respect to slow rotators
  - Observed in Pleiades and few young clusters of 30-50 Myr (e.g. Soderblom et al. 1993, Randich et al. 1998)

- GES iDR4 ⇒ correlation also at 5 Myr (NGC 2264, Bouvier et al. 2016)

- Several possible interpretations but no fully satisfactory explanation ⇒ other GES clusters can provide additional insights
Main-sequence Li depletion

- MS Li depletion not yet well understood (e.g. spreads, metallicity dependence)
- Previous studies limited to few clusters, not homogeneous
- Many more clusters and homogeneous data in GES iDR5

Li vs age, similar metallicity

Li vs metallicity, same age (3 Gyr)
Li-rich giants

- Li-rich giants ($A(\text{Li}) \geq 2$ dex) not expected from standard models
- Rare and difficult to find $\Rightarrow$ high potential for new discoveries in GES thanks to high statistics
- iDR4: 2 in Tr20 + 20 in the field (Smiljanic et al. 2016, Casey et al. 2016)
  - 9 in Corot (fraction $\sim 1\%$)

- 19 new in iDR5
  - 11 in Corot, 7 with $A(\text{Li}) \sim 3.5 - 3.6$
  - + 2 in Bulge
  - $\sim 1\%$ of new Corot giants with Li, consistent with iDR4 results
Li in globular clusters

- Li in GCs useful to test mixing and multiple populations

- Large sample of GCs with different metallicity and mass, and different gravities ⇒ quantitative constraints on both aspects

(Pancino, Franciosini et al., in prep.)
Residual problems

- Different number of measures from different nodes in WG10 (∼80% vs 20-30%)

- Discrepancies at low abundances

- Discrepant error distributions
Suggestions for improvements in iDR6

- Blind tests on fake spectra with different parameters, A(Li) and SNR to identify and correct residual measure problems
- Improve determination of uncertainties to obtain more reasonable values
- Obtain reliable measurements of upper limits
- Ensure consistent homogenisation procedures for problematic cases (e.g. mix of detections and upper limits, consistency between EW and abundances, etc...)

Lithium in GES is unique dataset ⇒ need for highest possible homogeneity and accuracy to fully exploit its potentialities