Study of atomic diffusion and additional mixing on lithium problem in solar-type stars

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BACKGROUND OF THE PROBLEM

- Lithium can only survive at the surface region of a star until the convection zone (CZ)

- The abundance predicted is not in agreement with the photospheric observations or helioseismology finding.

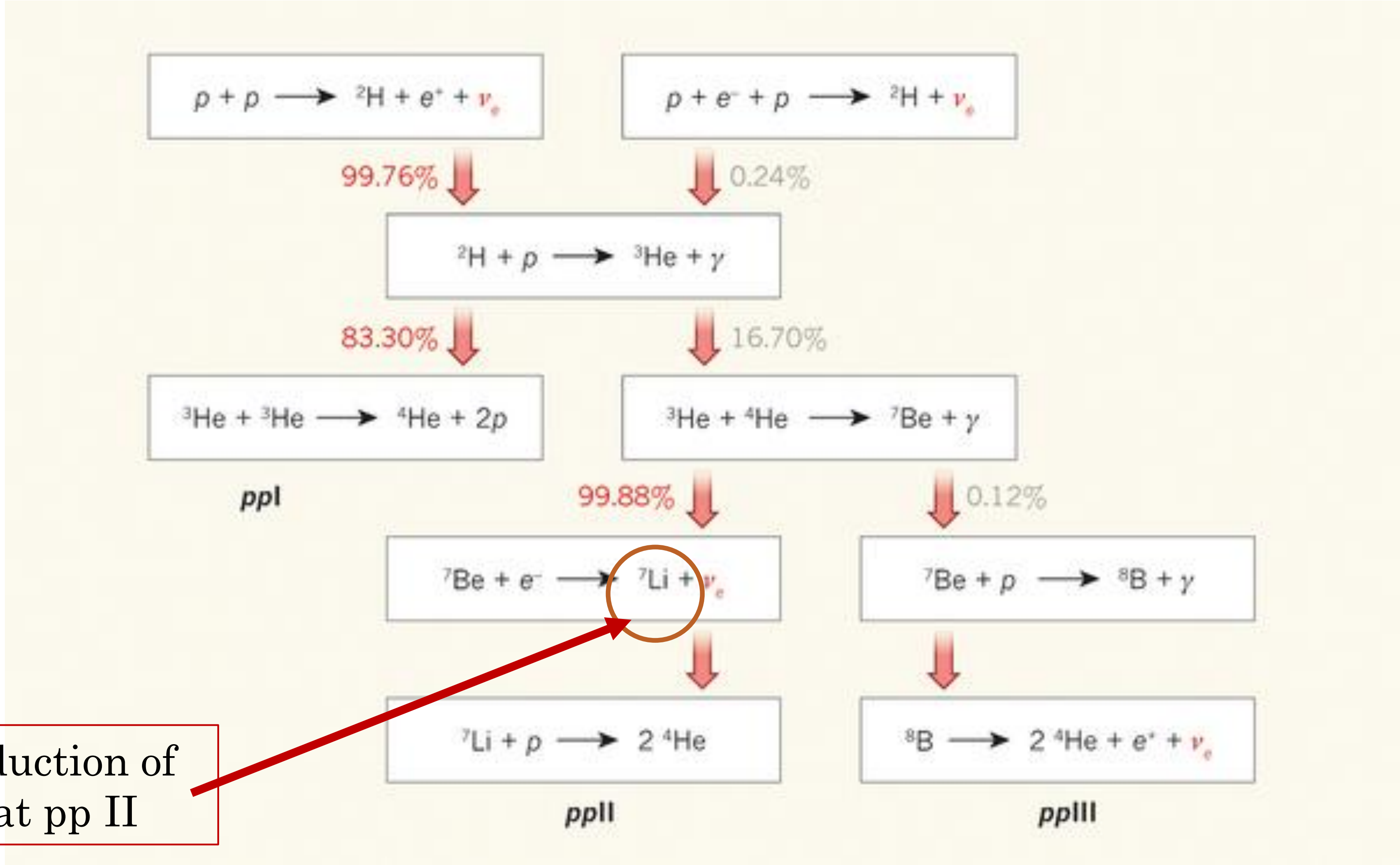
- Sources of Lithium Abundance :

  *Primordial Nucleosynthesis (Neglected)

  *Stellar Nucleosynthesis

Background of the problem

Proton-Proton Chain



Production of 7Li at pp II

Background of the problem

- The problems arising during the main sequence stage are

  (a) The current observations of lithium abundance on the sun's surface is 140 times lower compared to its protosolar value (Garik Israelian et al, 2009)

  (b) The comparison made between sun and its virtually identical stars in the solar-age M67 showed that 40% of the star members have lithium abundance comparable to the sun whereas the remaining 60% have 10 times more lithium (L.Pasquini et al,1997).

$T^{-\alpha}$

Background of the problem

- Suggest that depletion is not entirely dependent on star's age and even its stellar mass.
- The rate of lithium depletion is not a continuous process where it cannot just simply be described by T^{-a} (P. Sestito et al,2005)
- For all intermediate-age and old open clusters, there is an abrupt lithium drop among the F stars, the so-called '*Boesgaard gap*' (Boesgaard et al,1986).

BACKGROUND OF THE PROBLEM

- The depletion becomes ineffective beyond an age of 1–2 Gyr for the majority of the F late stars, leading to a Li plateau at old age (Boesgaard et al,1986).

PROBLEM STATEMENT

- To address the differences between observations and theoretical calculations by using stellar evolution model

- Focusing on solar-like stars in the current universe

Methods attempted during the past

- Convection treated with local mixing-length theory(Dr Xiong et al,1991) - *disagreement*
- Mixing due to convective overshooting(Dr Xiong et al,2002) - *disagreement*
- Rotationally induced mixing (P.Charbonneau et al,1988) - *disagreement*
- Transportation by gravity waves as main mixing process(Pinsonneault et ,1992) - *disagreement*
- Slow mixing induced by rotation and angular momentum loss model (P.Sestito et al,2005) - *disagreement*
- Extra mixing by magnetic field of Tyler-Spruit Dynamo type-field (T. D. Li et al,2014)- *promising*

Research objectives

1. To study the atomic diffusion effects on lithium abundance for solar-type stars
2. To investigate whether the atomic diffusion yield results that are consistent with the lithium abundance from helioseismology or observation perspectives

RESULT : HELIUM DIFFUSION

Table 1. Solar models for the three solar model sequences A (drawn), B (dashed), C (dotted): Mixing length parameter α, initial helium content Y_0, surface and central helium content Y_s and Y_c and central temperature T_c

Model sequence	Diffusion	α	Y_0	Y_s	Y_c	T_c in 10^6 K
A	0	1.64	26.99%	26.99%	61.69%	16.02
B	1	1.75	26.79%	25.63%	62.65%	16.12
C	3	1.96	26.39%	23.38%	65.12%	16.33

DIFFUSION DECREASES THE INITIAL HELIUM ABUNDANCE (J.Wambsganss,1998)

Research methodology

The works of the research will involve computational and analytical aspect using Victoria stellar evolution code (EVCODE)

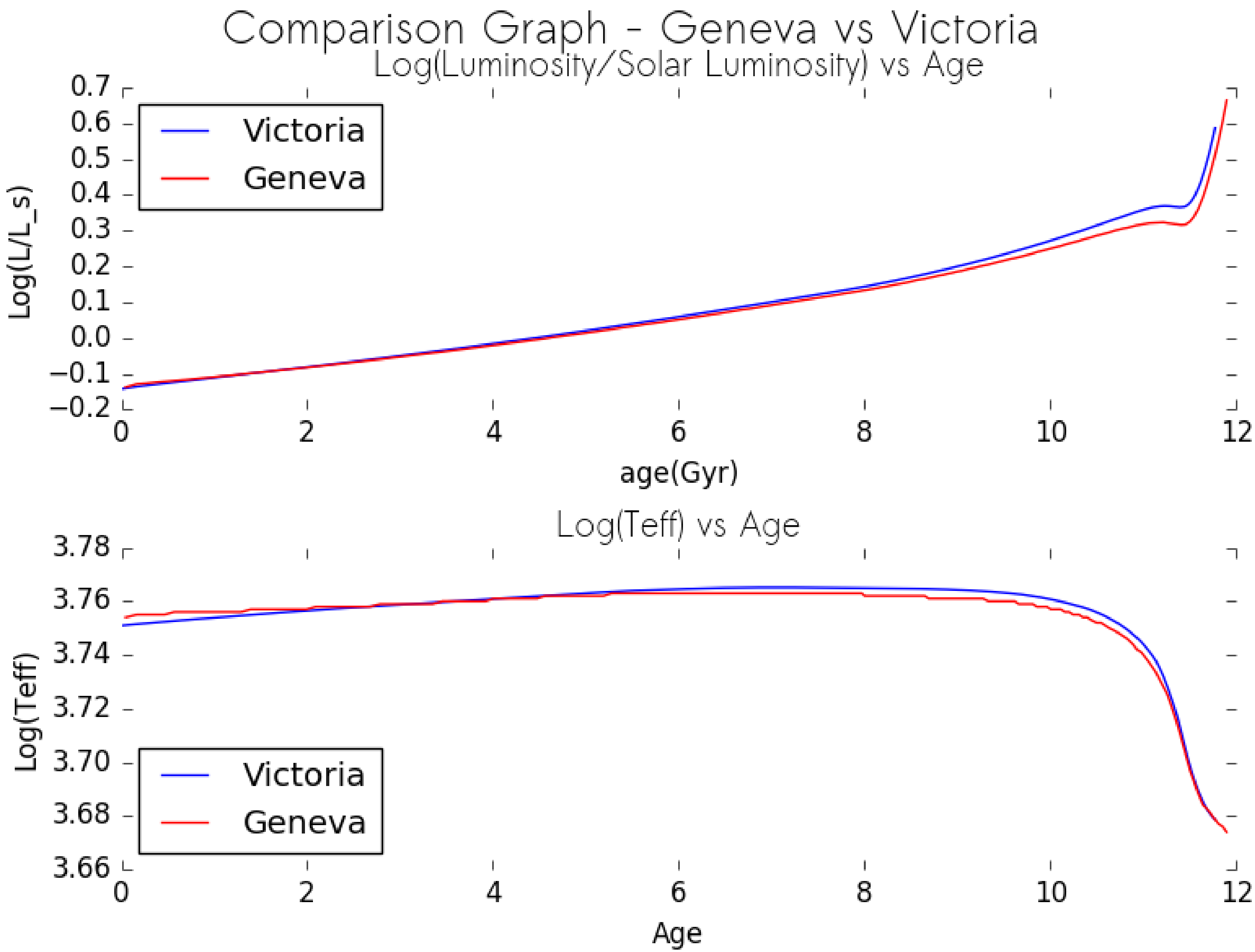
- To apply the mechanism for diffusion transport in solar-like stars
- To investigate the diffusion impact to the lithium's surface abundance of solar like stars
- To include diffusion transport mechanism in a stellar structure code

Research methodology

Brief description on the Victoria evolution code

- A stripped-down version of the pre-1992 University of Victoria stellar evolution program
- It employs 'Henyey' method
- Code is updated to the latest physics and newest parameters

1. Reaction Rates – Nacre (Angulo et al,1999)
2. Chemical Abundance – Asplund et al,2009
3. Opacity Table – OPAL 2005
4. Magnetic Field
7. Mixing Length Coefficient, α
8. Mass Loss


Comparison Graph - Geneva vs Victoria
Log(Luminosity/Solar Luminosity) vs Age
Victoria
Geneva
Log(L/L_s)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
−0.1
−0.2
0
2
4
6
8
10
12
age(Gyr)
Log(Teff) vs Age
Log(Teff)
3.78
3.76
3.74
3.72
3.70
3.68
3.66
Victoria
Geneva
0
2
4
6
8
10
12
Age

Significance of studies

- To improve our understanding in stellar transport mechanisms for solar type stars like our sun.

REFERENCES

1.Garik Israelian et al. *Enhanced lithium depletion in Sun-like stars with orbiting planets*, Nature 462, 189-191 (2009)

2. L. Pasquini et al. *Lithium in M67*, A&A, 325 (1997)

3. P. Sestito et al. *Time scales of Li evolution*

A&A, 3482 (2005)

4. Boesgaard et al.*Lithium in early F dwarfs,*ApJL, 30 (1986)

5. P. Ventura et al. *Pre-main sequence Lithium burning,* F. A&A, 334:953 (1998).2, 49 (1986)

6. Dr Xiong et al, *The surface lithium and beryllium depletions of the sun* (1991)

7. P Charbonneau et al. *Meridional circulation and the lithium abundance gap in F stars*. Ap. J., 334, 746 (1988)

8. Pinsonneault et al.*Evolutionary models of halo stars with rotation. II-Effects of metallicity on lithium depletion, and possible implications for the primordial lithium abundance (1992)*

9. T. D. Li et al.*Effects Of Magnetic Fields On Lithium Evolution In F And G Stars* (2014)

10. *J.Wambsganss,Helium and Hidrogen Diffusion in solar model* (1998)