

## WORKING GROUP on ABUNDANCES IN RED-GIANTS

<b>CHAIR</b>	<b>John C. Lattanzio</b>
<b>VICE-CHAIR</b>	<b>Jacco van Loon</b>
<b>BOARD</b>	<b>Pavel Denissenkov</b>
	<b>Paul Hauschildt</b>
	<b>Josef Hron</b>
	<b>Thomas Lebzelter</b>
	<b>Maria Lugaro</b>
	<b>Chris Tout</b>
	<b>Robert F. Wing</b>
	<b>Ernst Zinner</b>
	<b>Lucy Ziurys</b>

### TRIENNIAL REPORT 2009-2011

#### 1. Introduction

The WGARG was created in 2001 to oversee the rapid growth of the quantitative determination and understanding of the abundance patterns seen in red-giant stars. As the field progresses we are regularly reminded of how broad and multi-disciplinary is this area of research.

#### 2. Activities in the past triennium

##### 2.1. *Ongoing activities*

The WG webpage recently moved to a new address:

<http://users.monash.edu.au/~johnl/wgarg/>

Our monthly newsletter is edited by the Vice-Chair Jacco van Loon and Albert Zijlstra. It is called “The AGB Newsletter” and currently has approximately 1000 subscribers.

##### 2.2. *Specialist meetings*

The WG assisted the Vienna group in the organization of the second meeting in the “Why Galaxies Care About AGB Stars” series. This took place in August 2010 at the University of Vienna. As for the first meeting of this small series in 2006, the IAU working group on Abundances in Red Giants was actively involved in the discussion on the topical focus and supported the conference by promoting it actively via its members and its mailing list. Several members of the working group played a key role in the scientific and local organization. The conference was very successful with more than 170 participants discussing current research in the area of AGB stars and the relation to stellar populations. A focus of the meeting was set on the most recent and forthcoming instrumental developments. A considerable number of members of our IAU working group participated in this conference which opened the possibility to discuss and exchange most recent observational and modelling results both within the scientific program and in informal talks. The proceedings of the conference, edited by Franz Kerschbaum, Thomas

Lebzelter, and Robert Wing, have been published as volume 445 of the Astronomical Society of the Pacific Conference Series.

### 3. Developments within the past triennium

#### 3.1. *Deep-Mixing in red-giants*

The search for understanding of deep-mixing in red-giants continues. While thermohaline mixing has many promising attributes, eg Stancliffe (2010); Cantiello & Langer (2010); Charbonnel & Lagarde (2010); Angelou *et al.* (2011), the first multi-dimensional numerical simulations are not as supportive (Denissenkov (2010), Denissenkov & Merryfield (2010), Traxler *et al.* (2011)) and remind us that although progress has been made, a full understanding still eludes us (see also Wachlin *et al.* (2011)).

#### 3.2. *Opacity for AGB envelopes*

Another significant development was the calculation of opacity tables for the low temperature envelopes of red giants, but with the effects of dredge-up included in the envelope composition (Lederer & Aringer (2009), Ventura & Marigo (2009), Marigo & Aringer (2009)). The extra opacity sources can significantly alter the envelope structure of these stars, with feedback on the mass-loss and hence the dredge-up and final evolution. Models which include these new opacities are just making their way into the literature.

#### 3.3. *Mass-loss*

To avoid duplication, the WG report on this topic is included in the report from Commission 35. Please see that section in Commission 35 report.

#### 3.4. *Multiple population in globular clusters*

To avoid duplication, the WG report on this topic is included in the report from Commission 35. Please see that section in Commission 35 report.

#### 3.5. *Observations*

For the first time, comprehensive observational studies are being carried out at millimeter wavelengths to examine the molecular composition of the envelopes of oxygen-rich supergiant/hypergiant stars. A 1 mm spectral line survey of VY Canis Majoris across the frequency range 210-285 GHz has been conducted using the Submillimeter Telescope (SMT) of the Arizona Radio Observatory (ARO; Tenenbaum *et al.* 2010a,b). This work has demonstrated that the chemistry of this envelope is dominated by SO<sub>2</sub>, SiO, and SiS, as well as H<sub>2</sub>O, although certain carbon-bearing molecules are also abundant, such as HCN and CS (Ziurys *et al.* 2009). Unusual species such as AlO, AlOH, and PO (Tenenbaum & Ziurys 2009, 2010; Tenenbaum *et al.* 2007) are also present in VY CMa. A similar observational study is currently being conducted of NML Cygnus.

#### 3.6. *Super-AGB Stars*

To avoid duplication, the WG report on this topic is included in the report from Commission 35. Please see that section in Commission 35 report.

#### 3.7. *Hydrodynamics*

One area that is having increasing impact is multi-dimensional hydrodynamical studies. These have been referred to above in relation to the thermohaline mixing mechanism, but continued progress in understanding “normal” convection is being made regularly (Arnett *et al.* (2009), Arnett *et al.* (2010), Arnett & Meakin (2011)). Such codes also have

application in unusual cases, such as when the mixing and nuclear burning timescales are similar (Stancliffe *et al.* (2011)). We can expect more improvements in this area in the future as increasing computing power enables us to tackle previously impractical problems.

#### 4. Looking Forward

The WG is closely involved in organizing the 2012 edition of the “Nuclei in the Cosmos” series, which will take place in August in Cairns, Australia. A number of satellite meetings on related topics are also expected to be held about the same time. One that the WG is planning will be dedicated to the subject of multi-dimensional hydrodynamics and the effect of such studies on our discipline.

#### 5. Closing remarks

The study of red giants is fundamental to many areas of modern astrophysics. These stars are not only intrinsically interesting, exhibiting many different and complex phenomena, but they are also crucial to many other branches of astrophysics because of their ubiquity, high intrinsic luminosity, and important role in nucleosynthesis. We expect the WG to be active for many years to come.

John C. Lattanzio  
*Chair of Working Group*

#### References

- Arnett, W. D., Meakin, C., & Young, P., 2009, *ApJ* 690 1715  
 Arnett, W. D., Meakin, C., & Young, P., 2010, *ApJ* 710 1619  
 Arnett, W. D. & Meakin, C. 2011, *ApJ* 733 78  
 Angelou, G., Church, R. P., Stancliffe, R. J., Lattanzio, J. C., & Smith, G. H., 2011, *ApJ* 728, 79  
 &antiello, M. & Langer, N., 2010, *A&A* 521, 9  
 Charbonnel, C. & Lagarde, N., *A&A* 522, 10  
 Denissenkov, P. A., 2010, *ApJ* 723, 563  
 Denissenkov, P. A. & Merryfield, W. J., 2011, *ApJ* 727, 8  
 Lederer, M. T. & Aringer, B., 2009, *A&A* 494, 403  
 Marigo, P. & Aringer, B., 2009, *A&A* 508, 1539  
 Stancliffe, R. J., 2010, *MNRAS* 403, 505  
 Stancliffe, R. J., *et al.*, 2011, *ApJ* in press.  
 Tenenbaum, E. D., Dodd, J. L., Milam, S. N, Woolf, N. J., & Ziurys, L. M., 2010a, *Ap.J. Suppl.*, 190, 348  
 Tenenbaum, E. D., Dodd, J. L., Milam, S. N, Woolf, N. J., & Ziurys, L. M., 2010b, *Ap.J. (Letters)*, 720, L102  
 Tenenbaum, E. D., Woolf, N. J., & Ziurys, L. M., 2007, *Ap.J. (Letters)*, 666, L29  
 Tenenbaum, E. D. & Ziurys, L. M., 2010, *Ap.J.(Letters)*, 712, L93  
 Tenenbaum, E. D. & Ziurys, L. M., 2009, *Ap.J.(Letters)*, 694, L59  
 Traxler, A., Garaud, P., & Stellmach, S., 2011, *ApJ* 728, 29  
 Ventura, P. & Marigo, P., 2009, *MNRAS* 399, 54  
 Wachlin, F. C., Miller Bertolami, M. M., & Althaus, L. G., 2011, *A&A* 533, 139  
 Ziurys, L. M., Tenenbaum, E. D., Pulliam, R. L., Woolf, N. J., & Milam, S. N., 2009, *Ap.J.*, 695, 1604