From the Steering Committee

On behalf of the ANITA steering committee, and especially our editors Richard Stancliffe and Alan Duffy, welcome to the first ANITA newsletter! This newsletter has three simple goals: to inform, to promote, and to unify our small yet active theory community. We will publish each newsletter quarterly with a common format, covering news, reviews and research relevant to Australian theory of all areas.

In this inaugural edition we report on the ASA/ANITA Summer School on Nucleosynthesis held at Monash University in January, and the Fourth ANITA & companion gSTAR Workshop held at Swinburne University in March. We also give a round up of recent news relevant to the Australian theoretical community, as well as recently submitted/published theoretical papers. Starting next newsletter, in a regular series we’ll showcase a different Australian theory group and their research highlights (suggestions welcome). Each newsletter will be rounded out with a list of recent publications from the Australian theoretical community (please submit your abstracts for us to publish).

Our most recent exciting announcement is the new ANITA website: http://anita.edu.au/. Check there for all the latest ANITA news and information, and more general national and international news related to astro theory. We’ve also set-up an easy to use registration page. Those interested in joining ANITA should find this a quick and efficient way to do so.

Importantly, this newsletter belongs to the community. We would love to hear from you! If you have anything you would like to see in the newsletter; advertisements of jobs, workshops, conferences, or requests for the community, then please get in touch!

Darren Croton (convenor), Alan Duffy (editor) and Richard Stancliffe (editor)
News in brief

Elections
Following this year’s election, the ANITA steering committee consists of (starting 1st April 2010): convener Darren Croton (Swinburne), Tamara Davis (Queensland), Alan Duffy (UWA/ICRAR), Jarrod Hurley (Swinburne; all two year terms), Geoff Bicknell (ANU), Andrew Melatos (Melbourne), Gregory Poole (Swinburne), Stuart Wyithe (Melbourne; all one year terms), student representative Loren Bruns (Melbourne) and immediate past convenor John Lattanzio (Monash).


GPU powered astronomy
GPU machines are certainly on the rise. While Australian researchers look forward to access to the gSTAR GPU supercomputer, the Japanese community has recently secured funding for a 2.4 PetaFlop GPU cluster to be housed at the Tokyo Institute of Technology (TiTech). For those looking to perform GPU work on scales beyond those offered by gSTAR, you may be interested to hear that TiTech have stated that they wish to pursue the spirit of “everyone’s supercomputer” and make their huge computing power available to academic and industry users across the globe.


ANITA meeting
There will be a one-hour ANITA town hall meeting at the ASA in Hobart on Tuesday July 6th, starting at 1pm.

http://anita.edu.au/2010/06/21/town-hall-meeting/

ANITA does popular science / ANITA is a cover-girl
Scientific American’s July cover story features an article written by one of our very own ANITA members, Tamara Davis. Where does the energy go when photons are redshifted by the expansion of the universe? Is the total energy in the universe conserved? For the answers to these and other conundrums related to the surprisingly subtle issue of conservation of energy in the expanding universe, check out:

Globe-trotting PhD theorists
At the end of June, PhD students Lila Warszawski (University of Melbourne) and Christopher Hales (SIFA, ATNF), along with 12 other Australian students and early career researchers, will attend the 60th Nobel Laureate meeting on the island of Lindau, Germany. The meeting brings together over 500 graduate students from around the globe and 61 Nobel Laureates from the fields of medicine, physics and chemistry. For six days the students and Laureates attend a busy program of lectures, informal discussion sessions and social activities, with a view to promoting the transfer of knowledge across disciplines and generations. Attendance by Chris and Lila is supported by the Australian Academy of Science. Chris’ PhD work at SIFA and ATNF focusses on measurements of large-scale intergalactic magnetic fields, and Lila works at Melbourne University on theoretical models of pulsar glitches.

Andrew Melatos

Further news Please visit http://anita.edu.au/news/ to see these and subsequent news stories as we post them. If you have any additional stories that you would like to see posted on the ANITA website, please email gpoole@astro.swin.edu.au

Greg Poole (news editor)

Recent Activities

The 2010 ANITA and gSTAR Theory Workshops
On March 22nd-23rd 2010 Swinburne University played host to the fourth ANITA Theory Workshop. The goals of the workshop were fourfold: (a) to provide a review of Theoretical Astrophysics in Australia and a platform for current research, (b) to facilitate collaboration between theorists and observers, (c) to promote a sense of community among theoretical astrophysicists, and (d) to educate students and enhance their opportunities in the Australian and international community. In all of the above respects I feel the workshop was a great success!

We partnered the ANITA workshop with a single day workshop on the 24th to discuss opportunities for the new gSTAR GPU supercomputer. gSTAR is the result of a successful $1M EIF bid, to be housed at Swinburne’s Centre for Astrophysics and Supercomputing as part of their 2011 multi-million dollar supercomputer upgrade. This investment will buy the Australian astronomy community roughly a 40% share in a ∼ 600 Teraflop GPU supercomputer.

Across the three days we had a total of 43 registered participants, with 18 ANITA talks and 11 gSTAR talks. Talk topics covered a broad range of astrophysical problems: reionisation in the early Universe, star clusters, planet formation, galaxy formation, micro-lensing, dark matter, N-body and hydrodynamic simulations, computational algorithms, pulsars, dark
energy and cosmology. Congratulations to Lila Warszawski from the University of Melbourne for winning this years ANITA student prize for her talk on Understanding pulsar glitches from first principles. Further information on both workshops can be found at http://astronomy.swin.edu.au/anita/workshop2010/

We are currently planning for the next ANITA workshop to be held in Perth early 2011, and are considering partnering it with a theory summer school (to be announced). Watch this space!

Darren Croton (workshop organiser)

ASA/ANITA Summer School at Monash
The beginning of the year saw Monash University play host to the ASA/ANTIA summer school. Held from the 17th to the 22nd of January, the school gave 28 postgraduate students from around Australia an introduction to stellar nucleosynthesis. Travel scholarships were also provided to allow 14 undergraduate students to attend. Each day consisted of a morning of lectures, followed by an extended question and answer session from the lectures in the afternoon and rounding off with a ‘lab’ session, allowing students to work through problems on the topics of the day.

The school started off with Christian Iliadis (North Carolina, U.S.A.) covering basic nuclear theory and reaction rates. John Lattanzio (Monash) then covered hydrogen and helium burning reactions. Basic stellar structure was explained by Richard Stancliffe (Monash) and he also described the evolution of low-mass stars up to helium burning, with Lattanzio dealing with their helium burning lives. Amanda Karakas (RSAA, ANU) rounded off the discussion of low-mass stellar evolution, describing the asymptotic giant branch phase. Neutron capture reactions were then discussed, with Ross Church (Lund Observatory, Sweden) tackling the s-process, and Iliadis dealing with the r-process. The evolution of massive stars was discussed at length by Alessandro Chieffi (Rome, Italy) and Marco Limongi (Rome, Italy). Having dealt with single stellar evolution, the school then moved on to binary stars. Christohper Tout (Cambridge, U.K.) lectured on binary stellar physics, and Duncan Galloway (Monash) talked about X-ray bursts. Chiaki Kobayashi (RSAA, ANU) discussed Galactic Chemical
evolution theory. The observational side of stellar astronomy was covered by Gayandhi De Silva (AAO), with Janaina Avila (ANU) talking about meteoritic pre-solar grains.

The local organising committee would like to thank the sponsors listed below for supporting this meeting with cash contributions:

- Astronomical Society of Australia
- The Centre for Stellar and Planetary Astrophysics
- The School of Mathematical Sciences
- The School of Physics
- The Faculty of Science
- Marketing and Student Recruitment (Monash University)
- Dr Maria Lugaro
- Dr Duncan Galloway
- Prof John Lattanzio

We also thank the Harmon Group of hotels for providing inexpensive accommodation for the speakers, and excellent meals for everyone! And a special thanks to Marie Newington for her help in organising everything!

*John Lattanzio and Richard Stancliffe*
Publications

Below is a list of publications from the ANITA community for the first half of this year. If you have a publication you’d like to include for the next edition, then please e-mail Richard.Stancliffe@monash.edu. Be sure to use “Publication for ANITA newsletter” as the subject, and please supply the title, authors, abstract and a URL to where a copy of the paper can be found (e.g. a link to astro-ph).

**Impact of baryon physics on dark matter structures: a detailed simulation study of halo density profiles**

Alan R. Duffy, Joop Schaye, Scott T. Kay, Claudio Dalla Vecchia, Richard A. Battye, C. M. Booth

The back-reaction of baryons on the dark matter halo density profile is of great interest, not least because it is an important systematic uncertainty when attempting to detect the dark matter. Here, we draw on a large suite of high resolution cosmological hydrodynamical simulations, to systematically investigate this process and its dependence on the baryonic physics associated with galaxy formation. The inclusion of baryons results in significantly more concentrated density profiles if radiative cooling is efficient and feedback is weak. The dark matter halo concentration can in that case increase by as much as 30 (10) per cent on galaxy (cluster) scales. The most significant effects occur in galaxies at high redshift, where there is a strong anti-correlation between the baryon fraction in the halo centre and the inner slope of both the total and the dark matter density profiles. If feedback is weak, isothermal inner profiles form, in agreement with observations of massive, early-type galaxies. However, we find that AGN feedback, or extremely efficient feedback from massive stars, is necessary to match observed stellar fractions in groups and clusters, as well as to keep the maximum circular velocity similar to the virial velocity as observed for disk galaxies. These strong feedback models reduce the baryon fraction in galaxies by a factor of 3 relative to the case with no feedback. The AGN is even capable of reducing the baryon fraction by a factor of 2 in the inner region of group and cluster haloes. This in turn results in inner density profiles which are typically shallower than isothermal and the halo concentrations tend to be lower than in the absence of baryons.

Accepted for publication in MNRAS. Available from astro-ph.

**Does GD 356 have a Terrestrial Planetary Companion?**

Dayal T. Wickramasinghe, Jay Farihi, Christopher A. Tout, Lilia Ferrario, Richard J. Stancliffe

GD 356 is unique among magnetic white dwarfs because it shows Zeeman-split Balmer lines in pure emission. The lines originate from a region of nearly uniform field strength (delta B/B is approximately 0.1) that covers 10 per cent of the stellar surface in which there is a
temperature inversion. The energy source that heats the photosphere remains a mystery but it is likely to be associated with the presence of a companion. Based on current models we use archival Spitzer IRAC observations to place a new and stringent upper limit of 12 Jupiter masses for the mass of such a companion. In the light of this result and the recent discovery of a 115 min photometric period for GD 356, we exclude previous models that invoke accretion and revisit the unipolar inductor model that has been proposed for this system. In this model a highly conducting planet with a metallic core orbits the magnetic white dwarf and, as it cuts through field lines, a current is set flowing between the two bodies. This current dissipates in the photosphere of the white dwarf and causes a temperature inversion. Such a planet is unlikely to have survived the RGB/AGB phases of evolution so we argue that it may have formed from the circumstellar disc of a disrupted He or CO core during a rare merger of two white dwarfs. GD 356 would then be a white dwarf counterpart of the millisecond binary pulsar PSR 1257+12 which is known to host a planetary system.


Is Extra Mixing Really Needed in Asymptotic Giant Branch Stars?
Amanda I. Karakas, Simon W. Campbell, Richard J. Stancliffe

(Abridged) We demonstrate that the amount of extra mixing required to fit the observed low C/N and $^{12}$C/$^{13}$C ratios in first giant branch (FGB) stars is also sufficient to explain the C and N abundances of Galactic AGB stars. We simulate the effect of extra mixing on the FGB by setting the composition of the envelope to that observed in low-mass FGB stars, and then evolve the models to the tip of the AGB. The inclusion of FGB extra mixing compositional changes has a strong effect on the C and N abundance in our AGB models, leading to compositions consistent with those measured in Galactic C-rich stars. The composition of the models is also consistent with C abundances measured in mainstream silicon carbide grains. While our models cover the range of C abundances measured in C stars in NGC 1846, we cannot simultaneously match the composition of the O and C-rich stars. Our models only match the O isotopic composition of K and some M, MS giants, and are not able to match the O composition of C-rich AGB stars. By increasing the $^{16}$O intershell abundance (based on observational evidence) it is possible to reproduce the observed trend of increasing $^{16}$O/$^{18}$O and $^{16}$O/$^{17}$O ratios with evolutionary phase. We conclude 1) if extra mixing occurs during the AGB it likely only occurs efficiently in low metallicity objects, or when the stars are heavily obscured making spectroscopic observations difficult, and 2) that the intershell compositions of AGB stars needs further investigation.


Mergers in Lambda-CDM: Uncertainties in Theoretical Predictions and Interpretations of the Merger Rate
Philip F. Hopkins, Darren Croton, Kevin Bundy, Sadegh Khochfar, Frank van den Bosch, Rachel S. Somerville, Andrew Wetzel, Dusan Keres, Lars Hernquist, Kyle Stewart, Joshua

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D. Younger, Shy Genel, Chung-Pei Ma

Different methodologies lead to order-of-magnitude variations in predicted galaxy merger rates. We examine and quantify the dominant uncertainties. Different halo merger rates and subhalo ‘destruction’ rates agree to within a factor $\sim 2$ given proper care in definitions. If however (sub)halo masses are not appropriately defined or are under-resolved, the major merger rate can be dramatically suppressed. The dominant differences in galaxy merger rates owe to baryonic physics. Hydrodynamic simulations without feedback and older models that do not agree with the observed galaxy mass function propagate factor $\sim 5$ bias in the resulting merger rates. However, if the model matches the galaxy mass function, properties of central galaxies are sufficiently converged to give small differences in merger rates. But variations in baryonic physics of satellites have the most dramatic effect. The known problem of satellite 'over-quenching' in most semi-analytic models (SAMs), whereby SAM satellites are too efficiently stripped of gas, leads to order-of-magnitude under-estimates of the merger rate for low-mass/gas-rich/high-redshift galaxies. Fixing the satellite properties to observations avoids this and predicts higher merger rates, with residual factor $\sim 2$ uncertainties. Choice of mass ratio definition matters: at low masses, most true major mergers (in baryonic/dynamical galaxy mass) will appear to be minor mergers in their stellar or luminosity mass ratio. Observations and models using these criteria may underestimate major merger rates by factors $\sim 5$. Orbital parameters and gas fractions also introduce factor $\sim 3$ differences in amount of bulge formed by mergers, even for fixed mass ratio encounters.

Submitted to ApJ. Available on astro-ph

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Gravitational-wave spin-down and stalling lower limits on the electrical resistivity of the accreted mountain in a millisecond pulsar

Matthias Vigelius, Andrew Melatos

The electrical resistivity of the accreted mountain in a millisecond pulsar is limited by the observed spin-down rate of binary radio millisecond pulsars (BRMSPs) and the spins and X-ray fluxes of accreting millisecond pulsars (AMSPs). We find $\eta \geq 10^{-28} \text{s} (\tau_{\text{SD}}/1 \text{Gyr})^{-0.8}$ (where $\tau_{\text{SD}}$ is the spin-down age) for BRMSPs and $\eta \geq 10^{-25} \text{s} (M_a/M_E)^{0.6}$ (where $M_a$ and $M_E$ are the actual and Eddington accretion rates) for AMSPs. These limits are inferred assuming that the mountain attains a steady state, where matter diffuses resistively across magnetic flux surfaces but is replenished at an equal rate by infalling material. The mountain then relaxes further resistively after accretion ceases. The BRMSP spin-down limit approaches the theoretical electron-impurity resistivity at temperatures greater than around $10^5 \text{K}$ for an impurity concentration of $\sim 0.1$, while the AMSP stalling limit falls two orders of magnitude below the theoretical electron-phonon resistivity for temperatures above $10^8 \text{K}$. Hence BRMSP observations are already challenging theoretical resistivity calculations in a useful way. Next-generation gravitational-wave interferometers will constrain $\eta$ at a level that will be competitive with electromagnetic observations.

Synchronized formation of starburst and poststarburst galaxies in merging clusters of galaxies

Kenji Bekki, Matt S. Owers, Warrick J. Couch

We propose that synchronized triggering of star formation in gas-rich galaxies is possible during major mergers of cluster of galaxies, based on new numerical simulations of the time evolution of the physical properties of the intracluster medium (ICM) during such a merger event. Our numerical simulations show that the external pressure of the ICM in which cluster member galaxies are embedded, can increase significantly during cluster merging. As such, efficient star formation can be triggered in gas-rich members as a result of the strong compression of their cold gas by the increased pressure. We also suggest that these star-forming galaxies can subsequently be transformed into poststarburst galaxies, with their spatial distribution within the cluster being different to the rest of its population. We discuss whether this possible merger-induced enhancement in the number of star-forming and post-star-forming cluster galaxies is consistent with the observed evolution of galaxies in merging clusters.


A first direct measurement of the intergalactic medium temperature around a quasar at z=6


The thermal state of the intergalactic medium (IGM) provides an indirect probe of both the HI and HeII reionisation epochs. Current constraints on the IGM temperature from the Lya forest are restricted to the redshift range $2 < z < 4.5$, limiting the ability to probe the thermal memory of HI reionisation toward higher redshift. In this work, we present the first direct measurement of the IGM temperature around a $z=6$ quasar by analysing the Doppler widths of Lya absorption lines in the proximity zone of SDSS J0818+1722. We use a high resolution (R=40000) Keck/HIRES spectrum in combination with detailed numerical modelling to obtain the temperature at mean density, $T_0 = 23600_{-9000}^{+5000}K(\pm9200K)$ at 68 (95) per cent confidence assuming a prior probability $13500K < T_0 < 38500 K$ following HI and HeII reionisation. This enables us to place an upper limit on the redshift of HI reionisation, $z_H$, within 33 comoving Mpc of SDSS J0818+1722. If the quasar reionises the HeII in its vicinity, then in the limit of instantaneous reionisation we infer $z_H < 9.0(11.0)$ at 68 (95) per cent confidence assuming photoheating is the dominant heat source and that HI reionisation is driven by ionising sources with soft spectra, typical of population II stars. If the HI and HeII in the IGM around SDSS J0818+1722 are instead reionised simultaneously by a population of massive metal-free stars, characterised by very hard ionising spectra, we obtain a tighter upper limit of $z_H < 8.4(9.4)$. Initiating reionisation at higher redshifts produces temperatures which are too low with respect to our constraint unless the HI ionising sources or the quasar itself have spectra significantly harder than typically assumed.

Accepted for publication in MNRAS. Available on astro-ph.
The long and the short of it: modelling double neutron star and collapsar Galactic dynamics

Paul Kiel, Jarrod Hurley, Matthew Bailes

The work presented here examines populations of double compact binary systems and tidally enhanced collapsars. We make use of BINPOP and BINKIN, two components of a recently developed population synthesis package. Results focus on correlations of both binary and spatial evolutionary population characteristics. Pulsar and long duration gamma-ray burst observations are used in concert with our models to draw the conclusions that: double neutron star binaries can merge rapidly on timescales of a few million years (much less than that found for the observed double neutron star population), common envelope evolution within these models is a very important phase in double neutron star formation, and observations of long gamma-ray burst projected distances are more centrally concentrated than our simulated coalescing double neutron star and collapsar Galactic populations. Better agreement is found with dwarf galaxy models although the outcome is strongly linked to the assumed birth radial distribution. The birth rate of the double neutron star population in our models range from 4-160 Myr$^{-1}$ and the merger rate ranges from 3-150 Myr$^{-1}$. The upper and lower limits of the rates results from including electron capture supernova kicks to neutron stars and decreasing the common envelope efficiency respectively. Our double black hole merger rates suggest that black holes should receive an asymmetric kick at birth.

Accepted for publication in MNRAS. Available on astro-ph.