CPS 7th International School of Planetary Sciences

Theory of Stellar Evolution and Its Applications

--- From the First Stars to Planet-Hosting Stars and Gas Giant Planets ---

January 10-15, 2011

Hotel Seapal Suma, Kobe, Japan

CPS 7th International School of Planetary Sciences

Theory of Stellar Evolution and Its Applications

--- From the First Stars to Planet-Hosting Stars and Gas Giant Planets ---

January 10-15, 2011, Hotel Seapal Suma, Kobe, Japan

Hosted by
Center for Planetary Science (CPS) under the Global COE Program: "Foundation of International Center for Planetary Science", a joint project between Kobe University and Hokkaido University.

Organizing Committee

Advisory Committee

Ken-ichi Nomoto	IPMU, The University of Tokyo
Hiroyasu Ando	National Astronomical Observatory of Japan
Takashi Kozasa	Hokkaido University
Hiromoto Shibahashi	The University of Tokyo
Nobuo Arimoto	National Astronomical Observatory of Japan
Toshitaka Kajino	National Astronomical Observatory of Japan
Toshikazu Shigeyama	RESCEU, The University of Tokyo
Issei Yamamura	ISAS/JAXA
Wako Aoki	National Astronomical Observatory of Japan
Masahiro Ikoma	Tokyo Institute of Technology

Local Organizing Committee (* Chair, ** Scientific secretary, *** Secretary)

Masayuki Y. Fujimoto*	CPS, Hokkaido University
Takuma Suda**	Hokkaido University
Yutaka Katsuta**	Hokkaido University
Nozomu Tominaga**	Konan University
Hiroshi Kimura	CPS
Ko-ichiro Sugiyama	CPS
Yoshiyuki O. Takahashi	CPS
Seiya Nishizawa	CPS
Jun Kimura	CPS
Ayako Suzuki	CPS
Takayuki Tanigawa	CPS

Ko Yamada	CPS
Asako Sato***	CPS
Yoshiko Honjo***	CPS
Mire Murakami***	CPS
Mariko Hirano***	CPS
Yasuko Uematsu***	CPS

Program Committee

Masayuki Y. Fujimoto	CPS, Hokkaido University
Toshikazu Shigeyama	RESCEU, The University of Tokyo
Yoichi Itoh	CPS, Kobe University
Yuri Aikawa	CPS, Kobe University
Masahiro Ikoma	Tokyo Institute of Technology
Takuma Suda	Hokkaido University
Nozomu Tominaga	Konan University

CPS 7th International School of Planetary Sciences
Theory of Stellar Evolution and Its Applications
--- From the First Stars to Planet-Hosting Stars and Gas Giant Planets ---
January 10-15, 2011, Hotel Seapal Suma, Kobe, Japan

Monday, January 10, 2011

15:00	Registration Opens
17:00 - 18:00	Reception
18:00 - 19:30	Dinner
19:30 – 21:00	**Poster Session 1**

Tuesday, January 11, 2011

7:30 - 8:45	<Breakfast>
9:00 - 9:15	**Opening Talk**: Yushitsugu Nakagawa
9:15 - 10:15	**Lecture 1-1**: Daiichiro Sugimoto *Why the Stars and the Universe Evolve?*
10:15 - 10:30	<Break>
10:30 - 11:30	**Lecture 1-2**: Daiichiro Sugimoto *Fundamentals of Stellar Structure and Evolution*
12:30 - 13:30	<Lunch>
13:45 - 14:45	**Lecture 2-1**: Peter R. Wood *Evolution, Mass Loss and Variability of Low- and Intermediate-Mass Stars(1)*
14:45 - 15:00	<Break>
15:00 - 16:00	**Lecture 2-2**: Peter R. Wood *Evolution, Mass Loss and Variability of Low- and Intermediate-Mass Stars(2)*
16:00 - 16:15	<Coffee Break>
16:15 - 17:15	**Lecture 3-1**: Georges Meynet *Evolution of Massive Stars and the Effects of Rotation(1)*
17:15 - 17:30	<Break>
17:30 - 18:30	**Lecture 3-2**: Georges Meynet *Evolution of Massive Stars and the Effects of Rotation(2)*
19:00 - 20:00	<Dinner>
20:00 - 21:30	**Poster session 2 with short talks**

Wednesday, January 12, 2011

7:30 - 8:30	<Breakfast>
8:45 - 9:45	**Lecture 4-1**: Alexander Heger *Explosive Nucleosynthesis (1)*
9:45 - 10:00	<Break>
10:00 - 11:00	**Lecture 4-2**: Alexander Heger *Explosive Nucleosynthesis (2)*
11:00 - 11:15	<Break>
11:15 - 12:15	**Lecture 5** (hot topics): Shinya Wanajo *Recent progress of the r-process nucleosynthesis and electron-capture supernovae*
12:30 - 13:30	<Lunch>
13:45 - 14:45	**Lecture 6-1**: Stanley P. Owocki *Mass loss from Massive, Luminous Stars (1)*
14:45 - 15:00	<Break>
15:00 - 16:00	**Lecture 6-2**: Stanley P. Owocki *Mass loss from Massive, Luminous Stars (2)*
16:00 - 16:15	<Coffee Break>
16:15 - 17:15	**Lecture 7-1**: Martin Asplund *The chemical composition of the Sun and solar-type stars (1)*
16:30 - 16:45	<Break>
17:30 - 18:30	**Lecture 7-2**: Martin Asplund *The chemical composition of the Sun and solar-type stars (2)*
19:00 - 20:00	<Dinner>
20:00 - 21:30	**Poster session 3 with short talks**

Thursday, January 13, 2011

7:30 - 8:30	<Breakfast>
8:45 - 9:45	**Lecture 7-3**: Martin Asplund *The chemical composition of the Sun and solar-type stars (3)*
9:45 - 10:00	<Break>
10:00 - 11:00	**Lecture 8-1**: Jonathan J. Fortney *Structure and Evolution of Gas Giant Planets (1)*
11:00 - 11:15	<Break>
11:15 - 12:15	**Lecture 8-2**: Jonathan J. Fortney *Structure and Evolution of Gas Giant Planets (2)*
12:30 - 13:30	<Lunch>
13:30 -	<Excursion>

Friday, January 14, 2011

7:30 - 8:30	<Breakfast>
8:45 - 9:45	**Lecture 9-1**: Andrea Ferrara *Star formation in the early Universe (1)*
9:45 - 10:00	<Break>
10:00 - 11:00	**Lecture 9-2**: Andrea Ferrara *Star formation in the early Universe (2)*
11:00 - 11:15	<Break>
11:15 - 12:15	**Lecture 10-1**: Eline Tolstoy *Chemical Evolution of the Milky Way and Local Group Galaxies (1)*
12:30 - 13:30	<Lunch>
13:45 - 14:45	**Lecture 10-2**: Eline Tolstoy *Chemical Evolution of the Milky Way and Local Group Galaxies (2)*
14:45 - 15:00	<Break>
15:00 - 16:00	**Lecture 11-1**: Arlette Noels *Asteroseismology: a tool to unveil stellar interiors (1)*
16:00 - 16:15	<Coffee Break>
16:15 - 17:15	**Lecture 11-2**: Arlette Noels *Asteroseismology: a tool to unveil stellar interiors (2)*
17:30 - 18:30	**Memorial Lecture for Prof. Chushiro Hayashi**: Daiichiro Sugimoto *The Discovery of Hayashi Phase and His Way of Thinking*
19:00 - 21:00	<Banquet>

Saturday, January 15, 2011

7:30 - 9:00	<Breakfast>
9:00	<End of School>

Poster (All posters will be on display Monday - Friday)

P-01 **Brett Addison**
Precision Doppler Velocities of Transiting Planets with AAT+CYCLOPS

P-02 **James Guillochon**
Understanding the Ejection and Disruption of Giant Planets and their Effect on the Stellar Hosts

P-03 **Yutaka Komiya**
Extremely Metal-Poor Stars and Formation of the Milky Way

P-05 **Yasunori Hori**
Gas Giant Formation with Small Cores Triggered by Envelope Pollution by Icy Planetesimals

P-06 **Takaya Nozawa**
Formation of Dust Grains in the Ejecta of Type Ia Supernovae

P-07 **Kiehunn Bach**
Detailed Radiative Transfer Schemes in the 3-D Hydrodynamical Solar Surface

P-08 **Takashi Yoshida**
Progenitor for Type Ic Supernova 2007bi

P-09 **Nathan Dickinson**
The Metal Content of Hot White Dwarf Spectra

P-10 **Tomoko Sorahana**
Analysis of CH4 Q-branch absorption at 3.3um in brown dwarf spectra with AKARI

P-11 **Shin-ichi Takehiro**
Boussinesq thermal convection in a rotating spherical shell with an outer stably stratified layer

P-12 **Marcelo Miller Bertolami**
The diffusion induced nova scenario

P-13 **Takashi Moriya**
Ultraviolet-Bright Type IIP Supernovae and Extensive Mass-Loss

of Red Supergiants

P-14 Takuma Suda
A Chemical Probe into the Star Formation History of Our Galaxy Using the SAGA Database

P-15 Jun Takahashi
Polarimetry of Earthshine as a Test of Ocean Detection on Exoplanets

P-16 Taira Oogi
Dry Minor Mergers and Size Evolution of early-type galaxies in High Density Environments

P-17 Kazuhiro Kanagawa
The Relation between the Stellar Structure of Red Giants and the Formation and Evolution of Gas Giant

P-18 Patrick Baumann
Lithium depletion in solar-like stars: no planet connection

P-19 Sebastien Salmon
How asteroseismology can help to precisely constrain properties of planet-host stars.

P-20 Finny Oktariani
Global oscillation modes in the evolving disk of B emission stars

P-21 Aude Alapini
Probing the atmosphere of the 'hot jupiter' TrES-1b with HST

P-23 Zazralt Magic
On Using the Color-Magnitude Diagram Morphology of M67 to Test Solar Abundances

P-24 Kohei Inayoshi
Impact of cosmic ray/X-ray ionization on the supermassive black hole formation

P-25 Takayuki Tanigawa
Gas Accretion onto Circum-Planetary Disks

P-26 Sho Manabe
Search for unknown exoplanets by detection of transit timing variations

P-27 Shimako Yamada

Evolution of Zn,Co and Ba Enrichment of EMP Stars in the Framework of Hieratical Structure Formation

P-28 Youhei Sasaki

Weak-field dynamo emerging in a rotating spherical shell with stress-free top and no-slip bottom boundary

P-29 Andrew Mason

High Mass X-ray Binaries in the NIR. Orbital solutions of two highly obscured systems.

P-30 Nadine Nettelmann

Interior structure models of solar and extrasolar giant planets

P-31 Neil Miller

A correlation between the metallicity of planets and their host stars

P-33 Tetsuya Matsui

A crab of their flocks, a flock constructed by crabs

P-34 Daniel Bayliss

The Fraction of Stars Hosting Hot Jupiters

P-35 Melanie Godart

Theoretical instability strip of the upper part of the HR diagram

P-36 Kaori Otsuki

Neutron-capture and the r-process

P-37 Hiroko Ito

Lithium abundances of the most metal-poor turnoff stars

P-39 Natsuko Izutani

Nucleosynthesis in High-Entropy Hot-Bubbles of SNe and Abundance Patterns of Extremely Metal-Poor Stars

Lecture Abstract

Lecture I:

Why the Stars and the Universe Evolve ?
Fundamentals of Stellar Structure and Evolution

Daiichiro Sugimoto
Prof. Emeritus, The University of Tokyo

Part A. Why the Stars and the Universe Evolve?

Despite the second law of thermodynamics, the stars and the universe evolve. Their diversities have emerged by forming structures. Contrasts of densities and temperatures develop spatially and through the interior of a star. If we consider the whole region in space as a closed system, its total entropy is increasing. In a self-gravitating system, however, some open subsystems are automatically formed within the whole region. In some of the subsystems their entropies are decreasing while in others they are increasing to assure the increase of the total entropy of the whole region. The former subsystems are regarded as evolving by scarifying the others. Such characteristics are ascribed to the coupling between self-gravitation and thermodynamics. The system pretends to have apparent negative (gravothermal) specific heat, which leads to thermodynamic instability. It explains the mechanism of evolution in general. In this lecture we discuss mainly the case of stellar evolution, and add brief comments for the cases of stellar systems and the global universe.

Part B. Fundamentals of Stellar Structure and Evolution

Recently, evolution of the stars is computed numerically in great detail to interpret observations. Because of such advanced details it becomes more and more difficult to understand why such solutions result for the stellar structure. Here, we show how much we can interpret different phases of stellar evolution systematically without detailed numerical computation. Main concerns will not lie in local physics but ones determining the stellar structure and its secular change, i.e., evolution. For the former, important is its non-linear nature determining two different types of solutions, i.e., dwarf- and giant-types which are discriminated by different topologies in their characteristic plane. For the latter, important is its gravothermal nature as discussed in the preceding lecture of part A. Differently from conventional formulation, it is better to discuss stellar interior not in terms of density and temperature distributions but in density and pressure. Then, we can separate problems of structure from those of evolution, and understand different phases systematically from pre-main-sequence through pre-supernova stages including nuclear (shell-)flash, mass-loss, invasion of surface convection zone, etc.

Lecture II:

Evolution, Mass Loss and Variability of Low- and Intermediate-Mass Stars

Peter Wood
Australian National University, Australia

The evolution of low mass stars (M/Msun <∼ 2) and intermediate mass stars (∼ 2 < M/Msun <∼ 7) will be discussed, with particular emphasis on the late stages of stellar evolution. In these stages of stellar evolution, nucleosynthetic products from the stellar interior are transported to the stellar surface and stellar pulsations occur driving extensive mass loss. The mass loss leads to termination of the star's nuclear-burning lifetime. The stellar remnants of this process are post-AGB stars, planetary nebula nuclei and white dwarfs. The ejected material causes an enrichment of the interstellar medium in dredged-up nucleosynthetic products such as carbon, nitrogen and s-process elements. All these characteristic behaviours depend on the initial mass and metallicity of the stars. Observations that demonstrate these processes will be discussed and theoretical models of low and intermediate mass stars will be compared to observations. Many of the above processes are not well understood, and in nearly every case the cause of the uncertainly is our lack of a detailed understanding stellar convection and mixing. Attempts improve our understanding of these convective and mixing problems will be presented.

Lecture III:

Evolution of Massive Stars and the Effects of Rotation

Georges Meynet
University of Geneva, Switzerland

The lecture will begin by defining what is a massive star, and giving some of their general properties. Then we shall discuss three important physical ingredients which have a deep impact on how massive star evolves: mass loss by stellar winds, axial rotation and the effects of magnetic fields. A third part will focus on two specific questions of interest in the general theme of the school. The first question concerns the nature and the evolution of the first massive star generations in the Universe. We shall present arguments supporting the view according to which rotation plays a key role in shaping the production of some isotopes as ^{13}C, ^{14}N, ^{22}Ne and s-process elements in the early phases of the chemical evolution of our Galaxy. The second questions is related to the origin of short lived radionuclides in the nascent solar system. Some of these radionuclides indicates that massive stars have injected some of their products in the early solar systems. Implications for the nature of the environment at the time of the solar system formation will be discussed.

Lecture IV:

Explosive Nucleosynthesis

Alexander Heger
School of Physics and Astronomy, University of Minnesota, USA

The big bang only made hydrogen and helium; essentially all heavier elements were made by stars, including those elements needed to form planets and to sustain life. But how did the formation of these essential elements begin in the early universe and how did it carry on until today? What are the dierent processes that made the elements and how did they come here?

Today we have a reasonable understanding of the basic processes that made most of the elements and their isotopes. Some are made in stars up to several times heavier than our sun and then blown off their surface in enormous stellar winds. These asymptotic giant branch stars make most of the carbon and nitrogen, and about half of the heavier elements beyond iron. Essentially almost all of the rest is made inside even more massive stars, ten times the mass of the sun or more, and then released at the end of the brief life of these stars in a gigantic explosion, a supernova. Infact, the supernova not only ejects elements that were present in the star before, like most of the oxygen in the universe, but in the furnace of these explosion many new and exotic elements are forged, including, e.g., all the uranium and thorium, most of the intermediate elements below iron like silicon and calcium, about a third of the iron in the universe, and about half of the stable heavy isotopes. Understanding such supernova is the topic of this lecture.

I will give an overview of the different kinds of supernovae and what kind of stars make them. I will discuss how we anticipate the evolution of stars changes in general both depending on how massive they were born, and from what material they were made. The later changes as the universe evolves, as more stars die and enrich the universe with the ashes of previous generations of stars that are then incorporated in the next generation. I will show that the structure of the stars, how they explode, and hence also the elements they synthesis, does change depending on these varying initial conditions.

Unlike much of experimental physics, we cannot do direct experiments on stars in the laboratory – they are too unhandy. Instead, we can only rely on observational data, but must stars are far away and evolves on rather long time scales. Rather, much of our understanding of stars comes from observations and of course from theoretical and numerical modeling of the basic physics relevant to stars. But there are many uncertainties in the inputphysics, in particular the hydrodynamic instabilities. Some of them occur in conditions that are so extreme that they are hard to test in the laboratory or to simulate directly. Another ingredient of basic physics is that of the nuclear reactions that power the stars and that are responsible for making the elements we want to study. We will briefly discuss at some examples how the uncertainties of those can change our stellar models.

Lecture V:

Recent Progress of the r-Process Nucleosynthesis and Electron-Capture Supernovae

Shinya Wanajo
Technische Universität München, Excellence Cluster Universe, Germany

Half the elements heavier than iron in nature have been synthesized by the rapid neutron-capture process (r-process). These include rare-earth elements (yttrium, europium, dysprosium, ...), noble metals (silver, platinum, gold, ...), and actinides (thorium, uranium, plutonium, ...). Since the pioneering work of the r-process in 1950's, the astrophysical origin of these elements has remained a long-standing mystery. In the past decades, the neutron-rich ejecta of core-collapse supernovae (CCSNe) have been believed as the most promising site of the r-process. All the current r-process scenarios relevant to CCSNe are however facing severe difficulties. In particular, recent core-collapse simulations with neutrino transport show no sign of a neutron-rich outflow from the proto-neutron star. Recent one-dimensional (1D) hydrodynamical simulations of CCSNe with a sophisticated treatment of neutrino transport indicate the neutrino-driven outflows being proton-rich all the way until the end of their activity. New 2D explosion simulations of electron-capture supernovae (ECSNe; a subset of CCSNe) exhibit, however, convective neutron-rich lumps, which are absent in the 1D case. Our nucleosynthesis calculations indicate that these neutron-rich lumps allow for interesting production of elements between iron group and $N = 50$ nuclei (from Zn to Zr, with little Ga). Our models do not confirm, however, ECSNe as sources of the strong r-process (but possibly of a weak r-process up to Pd, Ag, and Cd in the neutron-rich lumps). We further discuss nucleosynthesis of the r-process in an alternative astrophysical site, "black hole winds", the neutrino-driven outflows from the accretion torus around a black hole. This condition is assumed to be realized in double neutron star mergers, neutron star – black hole mergers, or hypernovae, but we argue that conditions for strong r-processing are more likely to be realized in the merger case.

References

1. Wanajo, S. & Ishimaru, Y. 2006, *r-Process Calculations and Galactic Chemical Evolution*, Nuclear Physics A, 777, 676-699

2. Wanajo, S., Nomoto, K., Janka, H. -Th, Kitaura, F. S., & Müller, B. 2009, *Nucleosynthesis in Electron Capture Supernovae of AGB Stars*, Astrophysical Journal, 672, 208-220

3. Wanajo, S., Janka, H. -Th, & Müller, B. 2010, *Electron-Capture Supernovae as the Origin of Elements beyond Iron*, Astrophysical Journal, in press; arXiv1009.1000

4. Wanajo, S. & Janka, H. -T. 2010, *The r-Process in Black Hole Winds*, Origin of Matter and Evolution of Galaxies: OMEG-2010 / eds. T. Shima et al. (AIP Conference Proceedings), vol. 1269, p. 120-125

Lecture VI:

Mass loss from Massive, Luminous Stars

Stanley P. Owocki
University of Delaware, USA

Hot, massive stars of spectral types O and B have such high luminosities that the coupling of the star's radiative momentum to material at the stellar surface drives a strong, high-speed stellar wind outflow. The associated mass loss can be so strong that during the course of the star's evolution it strips away entirely the star's hydrogen envelope, leading to Wolf-Rayet (WR) stars in which the He and CNO products of earlier epochs nuclear burning are manifest as broad emission lines formed in the dense expanding stellar wind. The talk reviews the radiation hydrodynamics of such winds, with emphasis on the feedback of the wind acceleration on the principal driving force associated with the bound-bound line-scattering by metal ions. I discuss how the associated instabilities inherent in this line driving leads to a highly turbulent, clumpy wind. I also review how such wind outflows are affected by rapid stellar rotation, and/or by the strong magnetic fields recently discovered in some OB stars. Finally, I discuss how the eruptive mass loss from Luminous Blue Variable (LBV) stars might be a consequence of the stellar luminosity approaching or exceeding the Eddington limit, at which even the continuum scattering force overcomes gravity.

Lecture VII:

The chemical composition of the Sun and solar-type stars

Martin Asplund
Max Planck Institute for Astrophysics, Germany

Lectures:
1. Stellar atmospheres and spectroscopy
2. The solar chemical composition
3. Elemental abundances in stars with and without planets

The history of stars, galaxies and even the Universe as a whole is encoded in starlight, making stellar spectroscopy a central pillar of modern astrophysics ranging from studies of the Big Bang and the formation and evolution of galaxies to the births, lives and deaths of stars and the origin of the elements. Similar techniques are now also starting to be used to study extrasolar planets. To decipher the stellar spectra in terms of stellar parameters such as the chemical composition requires having realistic models of the stellar atmosphere and the radiative transfer. In stars such as the Sun, the modeling is greatly complicated by convection, which reaches up to the atmosphere and thus directly influences the spectrum formation. Traditionally, spectral analyses of late-type stars are based on stellar model atmospheres constructed within the framework of a 1D geometry and hydrostatic equilibrium and with convective energy transport estimated with the rudimentary mixing length theory (MLT). Recently, however, it has become feasible to make 3D, time-dependent, radiative-hydrodynamical simulations of stellar atmospheres, which have proven highly realistic when confronted with observations. Such 3D models give important insight to how stellar convection actually operates and can be used for the interpretation of stellar spectra and oscillations and as outer boundary conditions for stellar evolution calculations. A key finding is that convection is driven by radiative cooling in a very thin surface layers, which is distinctly different from the MLT picture of convection. In Lecture 1 I will discuss these advancements in stellar modeling and the physics of convection and radiative transfer.
I will then describe how these 3D hydrodynamical stellar/solar atmosphere models can be employed for abundance analysis. Lecture 2 will focus on the case of the Sun, where we have recently revisited the solar chemical composition and argued for a substantial downward revision of the previously adopted solar metallicity by almost a factor of two. In particular the most abundant metals ? C, N, O and Ne ? are much reduced due to a combination of the effects of using a 3D solar model, taking into account departures from local thermodynamic equilibrium, previously overlooked blends and improved atomic/molecular data, all of which happens to work in the same direction. The new solar abundances resolve the previously peculiar high metal content of the 4.5Gyr old Sun compared with young OB stars and ISM in the solar neighborhood. The revised solar metallicity, however, causes severe problems for standard solar interior models when contrasted with helioseismology data. Possible resolutions to this as yet unsolved so-called solar modeling problem will be discussed. The final lecture will be devoted to the chemical composition of solar-type stars, in particular a comparison of stars with and without exoplanets. Can the presence of planets be inferred from the particular elemental abundance signatures? Shortly after the first exoplanet was discovered, it was realized that the frequency of stars hosting planets increases rapidly with metallicity, which reflects the increased probability of forming planetesimals with more metals. I will discuss recent claims that exoplanet host stars on average have lower Li content than seemingly single stars and show that it is likely the result of selection effects.
Finally I will describe recent exciting results indicating that the Sun is indeed deficient in refractory elements compared with otherwise identical stars, solar twins. I will argue that this is a direct signature of the formation of planets in the solar system, indeed maybe even terrestrial planets. By extension we argue that some 10-20% of solar-like stars host planet systems similar to ours. This opens the truly enthralling prospect of using the detailed chemical compositions of stars to identify stars likely to host planets.

Lecture VIII:

Structure and Evolution of Gas Giant Planets

Jonathan J. Fortney
University of California, Santa Cruz, USA

I will discuss many aspects of the interior structure and thermal evolution of ”gas giant” and ”ice giant” planets. Our solar system’s gas giants are Jupiter and Saturn, and hundreds of similar planets have been found around other stars. Our solar system’s ice giants (thought to be composed primary of high-pressure water) are Uranus and Neptune, and dozens of examples exist around other stars. I will discuss theoretical and experimental insights into the equations of state of hydrogen, helium, water, and rock. Water and rock are thought to make up the central 10-15 Earth masses of all giants planets, perhaps as the initial seed core that triggered their formation. I will discuss our solar system’s planets is some detail, since these objects have been studied by spacecraft. Much of the discussion will focus on extrasolar planets, which have now been discovered across of a factor of 103 in age, and 105 in stellar insolation. The radiative atmosphere of a giant planet regulates the cooling of its predominantly convective interior, which leads to differences in cooling as a function of insolation. Results for current and future space missions, for solar system planets, and exoplanets, will be reviewed.

Lecture IX:

Star formation in the early Universe

Andrea Ferrara
Scuola Normale Superiore, Italy

I will first outline the physics of star formation in the primordial conditions prevailing after the Big Bang. All the relevant processes will be discussed in detail and the basic ideas behind the current understanding of the first stars will be reviewed. I will then concentrate on the production and dispersal of heavy elements and dust formed by the first stars and show how the presence of such species drastically changes the star formation mode by altering the cooling properties of the gas. The implications of such processes on cosmological scales will be elucidated. Finally, the theoretical framework will be analyzed in terms of the predictions for future searches of first stars both at high redshift and in the local Universe.

Lecture X:

Chemical Evolution of the Milky Way and Local Group Galaxies

Eline Tolstoy
University of Groningen, The Netherlands

Within the Local Universe galaxies can be studied in great detail star by star. The Color-Magnitude Diagram synthesis analysis method is well established as the most accurate way to determine the detailed star formation history of galaxies going back to the earliest times. This approach has benefited enormously from the exceptional data sets that wide field CCD imagers on the ground and the Hubble Space Telescope can provide. Spectroscopic studies using large ground based telescopes have allowed the determination of abundances and kinematics for significant samples of stars in the Milky Way and also in nearby dwarf galaxies. These studies have shown directly how properties can vary spatially and temporally, which gives important constraints to theories of galaxy formation and evolution.

Lecture XI:

Asteroseismology: a tool to unveil stellar interiors

Arlette Noels
Université de Liège, Belgium

Part 1:
1. Stellar oscillations across the HR diagram: During this trip among main sequence stars, red giants and white dwarfs, I shall briefly describe the types of pulsations that we may encounter.
2. Theory of stellar pulsations: I shall introduce the basics required to understand the information contained in stellar pulsations. In a first approach, adiabatic oscillations will be considered. Pressure and gravity modes will be discussed in relation to the Brunt-Väiaälä and the Lamb frequencies, defining their specific propagation cavities in the propagation diagram. We shall then discuss the non adiabatic case with an emphasis on the excitation mechanisms, namely the κ-mechanism and the stochastic excitation mechanism, and on the radiative damping occurring in highly condensed helium cores.
Part 2:
We shall discuss different types of stars for which asteroseismology can bring very important constraints on the global parameters but also on the physics involved in the computation of the internal stellar structure and we shall show in each case what physics can be learned from stellar pulsations.
1. Sun: The success brought up from helioseismology will be mentioned. We indeed now have a precise value of the surface helium abundance, of the depth of the convective envelope as well as important information as to the rotation law within the Sun. We shall show how the new solar abundances lead to a theoretical problem concerning the Sun internal structure.
2. Solar-like stars: The structure and the evolution of small mass stars are particularly affected by uncertainties in the amount of overshooting resulting in an additional mixing in the radiative region surrounding the convective core. Seismic analyses of solar-like CoRoT targets seem to bring a strong constraint on this parameter. We shall also give an example of what asteroseismology can add to the analysis of the Exoplanet System HD 17156.
3. Red giants: The large number of red giants showing non radial oscillations observed by CoRoT and Kepler allows a thorough population synthesis analysis which can lead to a better knowledge of the history of star formation in our Galaxy. Moreover the seismic identification of red clump stars constitutes a new distance indicator which, coupled with ground-based spectroscopic observations, will help deriving a metallicity gradient in the Galaxy, not only radially but also according to the depth in the galactic disk. We shall then turn to a detailed analysis of the stellar structure of red giants showing how asteroseismology can help pr?cising the evolutionary state, essentially discriminating between red giants ascending the red giant branch in the HR diagram and the red giants already in the core helium burning phase. A nice example of the seismic determination of the mass, the radius and the precise location of the helium second ionization zone will be illustrated with the CoRoT target HR7349.
4. SPB stars: With these stars, we shall show how the location and the shape of the chemical composition gradient surrounding the convective core can be constrained by asteroseismology and how it could be even possible to attribute the origin of a partial mixing to either a diffusive overshooting or rotation.
5. β Cephei stars: No oscillations are predicted for such stars if the metallicity is very low. In the small magellanic cloud however, β Cephei stars are claimed to have been detected. This could come from an underestimation of the opacity in the nickel-iron peak, responsible for the excitation mechanism in such stars.
6. Massive stars: We shall show of g-modes observed in post main sequence stars are the signature of an intermediate convective zone located above the helium core in the vicinity of the hydrogen burning shell and we shall discuss the physical reasons for the presence of such a zone. We shall also briefly address the possible detection of strange modes in the CoRoT target HD50064.

Memorial Lecture for Professor Chushiro Hayashi:

The discovery of Hayashi Phase and His Way of Thinking

Daiichiro Sugimoto
Prof. Emeritus, The University of Tokyo

One of the greatest astrophysicist, Professor Chushiro Hayashi passed away of age 89 years old on 28 February 2010. His life was admired in the obituary published in Astronomy and Geophysics (A&G, vol. 51: 3.36, 24 May 2010 by D. Sugimoto). His works cover mainly the stellar evolution and the origin of the solar system, and partly the early universe and the non-local field theory. In the present lecture we concentrate on stellar evolution and, in particular, his discovery of Hayashi Phase in 1961, which replaced Henyey contraction of the star through its passage from birth to a main-sequence star. During the Hayashi Phase the stellar interior remains almost wholly in convective equilibrium. As a result, the star passes through much more luminous stages as compared with the radiative Henyey contraction. It gives important effect to physical states of the solar nebula in which the planets grow. This is one of the reasons why he developed thereafter the Kyoto Model for the origin of the solar system. He reached such concepts of Hayashi Phase for the early phase of evolution while he was studying the late phase of evolution towards red-giant stars. He noticed that these two are a common problem so far as the outer boundary condition to the stellar interior is concerned. We follow his development of research and ways of thinking. In addition, we re-consider implications of the Hayashi Phase and his later researches for stellar evolution on the bases of the present day understanding of stellar structure that was discussed in the first lectures of this series given by myself.

Poster Abstract

Estimating spin-orbit alignment of transiting planetary systems by observing the RM effect using Cyclops.

Brett Addison[1] and Chris Tinney[1], [1]Department of Astrophysics and Optics, School of Physics, Faculty of Science, University of New South Wales, 2052, Australia. b.addison@student.unsw.edu.au

Introduction: Around 500 extrasolar planets have been discovered over the last decade and a half with many more to be discovered in the next couple of years. In addition to discovering new extrasolar planets, a detailed analysis of their structure, composition, and other bulk properties is also needed in order to gain an understanding of the processes involved in the formation of planets in other systems as well as in our own solar system. The Exoplanetary Science group at UNSW is commissioning a Cassegrain-fed optical-fibre bundle called CYCLOPS at the Anglo-Australian Telescope (AAT) to carry out Doppler spectroscopy of transiting planet candidate stars arising from Southern Hemisphere transit searches. In addition, our team will aim to carry out measurements of the Rossiter-McLaughlin (RM) effect in transiting exoplanets. The R-M effect is an anomaly in the radial velocity curve that arises when a planet blocks a small portion of its host stars disc that is either rotating towards or away from the viewer. The detection of this effect will allow us to estimate the orbital parameters and mass of transiting exoplanets which are critical components needed to study their structure and formation processes as well as their migration history.

CYCLOPS at the Anglo-Australian Telescope: CYCLOPS is an upgrade for the AAT's existing UCLES coude-echelle spectrograph. It replaces the five mirror Coude train, with a Cassegrain-fed optical-fibre bundle, which reformats an area of 4.7 square arcseconds on the sky (formatted as fifteen 0.6" diameter hexagons) into a pseudo-slit of 15 fibres at the entrance of UCLES. Each fibre at the entrance slit has a diameter of 0.61", which delivers a resolution of $\lambda/\Delta\lambda$ = 70,000. CYCLOPS is a "win-win" upgrade - commissioning tests demonstrate it delivers 30% more photons to our spectrograph than the old mirror train, and does so at 50% higher resolution.

Estimating the Spin-orbit Alignment of Transiting Exoplanets from Observing the Rossiter-McLaughlin Effect: RM observations deliver constraints on the alignment of the stellar spin ($v\sin i$) with the angle of the planetary orbit (λ) – this "spin-orbit" alignment provides critical imformation on the formation and migration of gas-giant planets. Using Cyclops + UCLES, our team will observe a number of transiting planet candidate stars arising from Southern Hemisphere transit searches during the transiting phase in order to measure the RM effect. Our team has also developed a theoretical model in IDL to estimate $v\sin i$ and λ by implementing a chi squared minimization analysis of the observed RV data during transit to our theoretical model. To test our model, we produced a theoretical model plot of the RM effect for the transiting exoplanetary system XO-2 as shown in Figure 1 with the following orbital, planetary, and stellar parameters[1,2]: $M^1_\star$ = $0.98M_\odot$, $R^1_\star$ = $0.964R_\odot$, M^1_p = $0.57M_J$, R^2_p = $1.036R_J$, i^2 = 89.79°, a^2 = 0.0358AU, e^2 = 0, λ^2 = 6.00°, and $v\sin(i)^2$ = 6.4km s^{-1}. Figure 2 shows the radial velocity curve of the entire orbit of XO-2b.

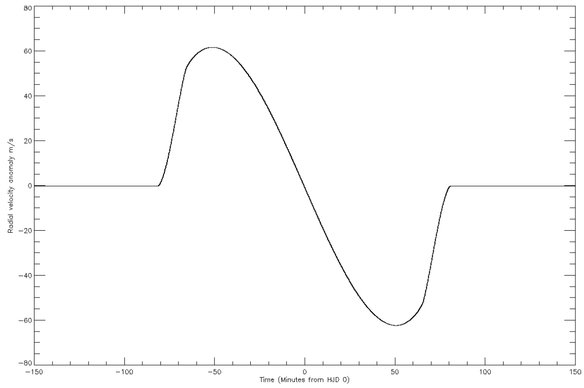


Figure 1 - The RM effect for the transiting planet XO-2b.

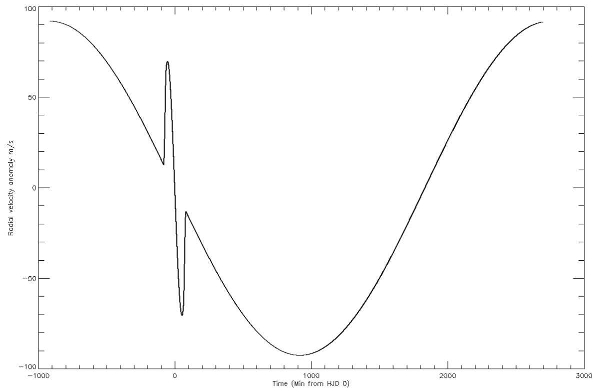


Figure 2 - The RV curve of the entire orbit for the transiting planet XO-2b.

Conclusion: The Exoplanetary Science group at UNSW has commissioned a Cassegrain-fed optical-fibre bundle spectrograph called Cyclops at the AAT to carry out Doppler spectroscopy and measurmenets of the RM effect of transiting planet candidate stars arising from Southern Hemisphere transit searches. This research will allow us to estimate the orbital parameters and mass of transiting exoplanets, critical components needed to study their structure and formation processes as well as their migration history.

---

1 Parameters for XO-2 system obtained from The Extrasolar Planets Encylopedia http://exoplanet.eu/

2 Parameters of XO-2 system determined by our model or assumed solar system values.

Understanding the Ejection and Disruption of Giant Planets and their Effect on the Stellar Hosts

James Guillochon[1], Enrico Ramirez-Ruiz[1], and Doug Lin[1]

ABSTRACT

The discovery of Jupiter-mass planets in close orbits about their parent stars has challenged models of planet formation. Recent observations have shown that a number of these planets have highly inclined, sometimes retrograde orbits about their parent stars, prompting much speculation as to their origin. It is known that migration alone cannot account for the observed population of these misaligned hot Jupiters, which suggests that dynamical processes after the gas disc dissipates play a substantial role in yielding the observed inclination and eccentricity distributions. One particularly promising candidate is planet-planet scattering, which is still not very well understood in the non-linear regime. Through three-dimensional hydrodynamical simulations, we show that planets that are scattered into an orbit about their parent stars with closest approach distance being less than approximately three times the tidal radius are either destroyed or ejected from the system completely. As the circularization time for hot Jupiters is comparable to the age of the host stars for slightly larger pericenter distances, only a very narrow range of scattering events will produce a system with a bound planet that survives as a hot Jupiter. If systems hosting hot Jupiters are representative of the general planet population, then this implies that either the number of scattering events per system must be large, or that scattering is not the dominant process. If planet-planet scattering is indeed the primary mechanism, we predict that planetary hosts which possess thin convective envelopes ($M > 1.2M_{\odot}$) are likely to exhibit super-solar rotation rates.

.

[1]Department of Astronomy and Astrophysics, University of California, Santa Cruz, CA 95064, USA

Extremely Metal-Poor Stars and Formation of the Milky Way

Yutaka Komiya

Extremely metal poor (EMP) stars are the very old stars formed in the early universe. They are probes to the first stars and formation of the Milky Way.
In previous studies, we investigate initial mass function (IMF) of EMP stars from statistics of carbon-enhanced EMP stars which are polluted by binary mass transfer, and show that typical mass of EMP stars are ~10 solar mass.
In this study, we investigate abundance distribution of EMP stars. We build hierarchical model for very early stages of chemical evolution of the Milky Way. We plant merger tree semi-analytically and compute chemical enrichment history along the tree. We gives computation results with high mass IMF peaked at 10 solar mass, and compare the results with Salpeter IMF.
We show the predicted distribution of relative abundance of alpha-elements, some iron group elements and r-process elements. We discuss the origin of these elements in comparison with observational distribution of the element abundances.

Gas Giant Formation with Small Cores Triggered by Envelope Pollution by Icy Planetesimals

Yasunori Hori & Masahiro Ikoma

Department of Earth and Planetary Sciences, Tokyo Institute of Technology

We have investigated how envelope pollution by icy planetesimals can change a critical core mass for gas giant formation and gas accretion time-scales. In the core-accretion model, the envelope of a protoplanet begins to increase in mass rapidly after a core reaches the critical core mass. The critical core mass is believed to be as large as 10 times Earth-mass. One of major concerns for the core-accretion model is to form gas giants with small cores such as Jupiter before disc gas dissipates. Previous works showed that reduction of grain opacities and a slow rate of planetesimal accretion lower the critical core mass and hasten gas accretion onto the protoplanet. However, all the previous studies assumed that the envelope has the solar composition uniformly. In fact, the envelope is likely polluted by evaporated materials of icy planetesimals because they going through the envelope experience strong ablation and most of their masses are lost in the envelope. We have demonstrated that envelope pollution can in general lower critical core masses and shorten time-scales of gas accretion onto the protoplanet. The increase in the molecular weight and reduction of adiabatic temperature gradient have contributions to trigger gas giant formation with small cores. Our results propose that gas giant formation must be considered based on the core-accretion model taking into account envelope pollution by icy planetesimals in the course of planetary accretion.

Formation of Dust Grains in the Ejecta of Type Ia Supernovae

Takaya Nozawa (IPMU, Univ. of Tokyo)

We investigate the formation of dust in the ejecta of Type Ia supernovae (SNe Ia), applying the nucleation and grain growth theory. In the calculations, we adopt the carbon-deflagration W7 model as a model of SNe Ia. The results of the calculations show that for the sticking probability of unity, C, silicate, Si, and FeS grains can form at 100--300 days after the explosion, while Fe and SiC grains cannot condense substantially. Because of the low gas density in SNe Ia with no H-envelope, the average radii of the newly formed grains are less than 0.01 mum, being smaller than those in Type II-P SNe. The total dust mass ranges from 3x10^{-4} to 0.02 Msun for the sticking probabilities of 0.1--1. We also estimate the optical depths and thermal emission by the newly formed dust and compare with the relevant observations. We find that the formation of C gains in SNe Ia should be suppressed to be consistent with the observational constraints. This indicates that energetic photons and electrons must disturb the nucleation of C grains or that the outermost C-O layer of SNe Ia must be burned. Finally, by calculating the destruction of dust through the passage of the reverse shock, we find that dust grains formed in the ejecta are completely destroyed in the shocked gas in the course of their injection into the interstellar medium. This implies that SNe Ia cannot be major sources of interstellar dust.

Detailed Radiative Transfer Schemes in the 3-D Hydrodynamical Solar Surface Convection

K. Bach[1], & Y.-C. Kim[2]

1. Yonsei University Observatory, Yonsei University, Seoul 120-749, Korea
2. Department of Astronomy, Yonsei University, Seoul 120-749, Korea

ABSTRACT

We have investigated the detailed non-grey radiative transfer scheme in the three dimensional hydrodynamical solar surface. Outer convection zone is extremely turbulent region composed of partly ionized compressible gases in high temperature. Especially, super-adiabatic layer (SAL) is the transition region where the transport of energy changes drastically from convection to radiation. In order to describe physical processes in SAL accurately, a realistic treatment of radiation should be considered as well as convection. For a detailed computation of radiative transfer, the Accelerated Lambda Iteration (ALI) methods have been applied to Large-Eddy Simulation (LES) with non-grey opacity schemes using the Opacity Distribution Function (ODF). Our computational domain is the rectangular box of dimensions $4^2 \times 3$ Mm with the resolution of $117^2 \times 190$ meshed grids, which covers several granules horizontally and $8 \sim 9$ pressure scale heights vertically. As the result of numerical simulation, we present the time-dependent variation of radiation fields and thermodynamic structures. In addition, our radiation-hydrodynamical computation has been compared with the classical approximations such as grey atmosphere and Eddington approximation.

Subject headings: stars : atmospheres – Sun : photosphere – numerical : hydrodynamics – numerical : radiative transfer

1.

Progenitor for Type Ic Supernova 2007bi

Takashi Yoshida and Hideyuki Umeda
Department of Astronomy, Graduate School of Science, University of Tokyo

---

SN 2007bi is an extremely luminous Type Ic supernova. Spectral analyses deduced the production of $3.6 - 7.4 M_\odot$ of radioactive ^{56}Ni. From the observations of light curve and spectra, this supernova was proposed as a pair-instability supernova (PISN) with a $\sim 100 M_\odot$ progenitor. On the other hand, the light curve was also fitted by a core-collapse supernova (CCSN) with a $\sim 43 M_\odot$ CO core progenitor. In order to constrain the explosion mechanism of this supernova, we investigate the evolution of very massive stars with $M_{\rm MS} = 100 - 500 M_\odot$ and $Z_0 = 0.004$ corresponding to the host galaxy of SN 2007bi. If this supernova is a PISN, the final CO core should be $M_{\rm CO} \sim 95 - 105 M_\odot$ and the corresponding main sequence mass is $M_{\rm MS} \sim 515 - 575 M_\odot$. A star with $M_{\rm MS} \sim 100 - 280 M_\odot$ evolves to a $M_{\rm CO} \sim 35 - 60 M_\odot$ progenitor appropriate for the CCSN of SN 2007bi. When Salpeter initial mass function is adopted to the ranges of the main-sequence mass for the PISN model and CCSN model, the population ratio of PISN progenitors to CCSN is about 0.02. We discuss the possibility of Type Ic supernova by considering the mass ratio of the He layer to intermediate layers, the total He mass, and the He mass fraction at the surface of a progenitor. We suggest that a WO star or a WC star with He-deficient surface would explode as Type Ic supernova. We also discuss the effect of uncertainties in the mass loss rate.

THE METAL CONTENT OF HOT WHITE DWARF SPECTRA

N. J. Dickinson[1*], M. A. Barstow[1], B. Y. Welsh[2], M. Burleigh[1], S. L. Casewell[1], J. Farihi[1], R. Lallement[3]

[1]*Department of Physics and Astronomy, University of Leicester, University Road, Leicester, LE1 7RH, UK*
[2]*Experimental Astrophysics Group, Space Sciences Laboratory, University of California, 7 Gauss Way, Berkeley, CA 94720, USA.*
[3]*Université Versailles St-Quentin; CNRS/INSU, LATMOS-IPSL, France*

[*]E-mail: njd15@le.ac.uk

Hot white dwarfs are brimming with metallic elements. While the predicted patterns between abundance and temperature are broadly seen in observations, the detailed, quantitative abundances seen in a given white dwarf are often not as predicted. The line profiles of a given absorption feature can often be difficult to reconcile with those predicted from theory. On occasion, there are also significant differences in the elemental abundances of hot white dwarfs with a similar effective temperature and surface gravity. It can therefore be inferred that processes other than radiative levitation, such as stellar winds, circumstellar material, accretion from a binary companion or possibly the accretion of disrupted planetary remnants can play an important role in the metal composition of these hot white dwarfs. Here, we present an analysis of the ultraviolet spectra of such hot white dwarfs, and discuss the possible reasons for their metal abundances.

Analysis of CH_4 Q-branch absorption at 3.3 μm in brown dwarf spectra with AKARI

S. Sorahana (The University of Tokyo / Institute of space and astronautical science, JAXA)

We present the result of our analysis about the appearance of 3.3 μm CH_4 band based on the 2.5–5.0 μm spectra of brown dwarfs taken by the Japanese infrared astronomical satellite, AKARI. Atmosphere of brown dwarfs are so cool and dominated by molecules and dust. The coolest brown dwarfs, classified as spectral type of T, are characterized by the presence of CH_4 band at 1.6 and 2.2 μm. On the other hand L-type brown dwarfs which higher temperature do not show the bands. Noll et al. (2000) detected the 3.3 μm CH_4 band in the L5-dwarf, 2MASS J1507-1627, while Nakajima et al. (2001) confirmed no presence of CH_4 band at 1.6 and 2.2 μm in this object. These results said that we need more investigation to understand how they appear in the infrared spectra. With the high quality AKARI spectra, we searched for presence of 3.3 μm CH_4 fundamental band. We found that the band is seen in the brown dwarfs as early as L5, and detected CH_4 in two of four sources. We derive the physical parameters of the atmosphere of the objects by applying the unified cloudy model (Tsuji 2002, 2005). We found that the sources with/without 3.3 μm CH_4 band have systematically different parameters. The abundance of CH_4 depends on more on the surface gravity and the critical temperature, which is a measure of the thickness of the dust cloud, than the effective temperature. We will explain the details of the analysis and discuss what the results indicate.

Boussinesq thermal convection in a rotating spherical shell with an outer stably stratified layer

Shin-ichi Takehiro†, Michio Yamada†, and Yoshi-Yuki Hayashi‡

†Research Institute for Mathematical Sciences, Kyoto University, Kyoto 606-8502, Japan

‡Department of Earth and Planetary Sciences, Kobe University, Kobe 657-8501, Japan

Numerical experiments of Boussinsesq thermal convection in a rapidly rotating spherical shell associated with a stably stratified layer placed near the outer surface are performed. It is shown that the existence of a strongly stratified upper layer enhances the generation of equatorial surface retrograde zonal flows when the Rayleigh number is approximately ten times larger than the critical value. When the stratification of the stable layer is sufficiently strong, the columnar convective vortices are trapped below the stable layer but the mean zonal flows still penetrate the layer and reach the outer surface.

The diffusion induced nova scenario

Marcelo Miguel Miller Bertolami

We propose an scenario for the formation of DA white dwarfs with very thin He-buffers. For these stars we explore the possible occurrence of diffusion induced CNO flashes during their early cooling stage. Based on physically sounding white dwarf models, we find that the range of helium buffers masses for these diffusion induced novas to occur is significantly smaller than the only previous study of this scenario. We, however, find that these flashes do occur in some low-mass and low metallicity remnants, about 10^6- 10^7 years after departing from the AGB. We present the expected lightcurves, timescales and abundances of these events and discuss possible observational counterparts. Contrary to previous speculations we find that these events are not recurrent and do not change, substantially, the final hydrogen content of the white dwarf.

Ultraviolet-Bright Type IIP Supernovae and Extensive Mass-Loss of Red Supergiants

Takashi Moriya

Massive red supergiants (RSGs) can experience a mass loss with a very high mass-loss rate due to the dynamical instabilities caused by the partial ionizations of hydrogen (e.g., Yoon & Cantiello 2010). It is suggested that the mass-loss rates of massive RSGs can be as high as 0.01 Msun/yr. Because of the mass loss, massive RSGs can have very dense circumstellar matter (CSM) around them. If a supernova (SN) explosion occurs soon after the extensive mass loss of RSGs, the SN ejecta will collide the dense CSM. Due to the collision, the kinetic energy of the ejecta is converted to radiation energy and such SNe with collision can be brighter , especially in ultraviolet, than the usual SNe of RSGs. By performing one dimensional multi-group radiation hydrodynamical calculations, we investigate the effects of the collision on SN LCs. We also compare our models with the ultraviolet-bright Type IIP SN 2009kf and show that the progenitor of SN 2009kf can be a massive RSG which experienced an extensive mass loss just before its explosion.

A Chemical Probe into the Star Formation History of Our Galaxy Using the SAGA Database

Takuma Suda

Extremely metal-poor stars in the Galactic halo are useful probes into the early evolution of the Universe because their surface chemical abundances reflect the composition of the gas in which they were born. Thanks to the HK and Hamburg-ESO survey, we have a handful of such stars enough to make statistical discussions. In this paper, we present our exploration of the chemical enrichment history of the Galaxy using the Stellar Abundances for Galactic Archaeology (SAGA) database (http://saga.sci.hokudai.ac.jp) that we have developed and compiled the data of observed metal-poor stars in the Galaxy. We find the transition of the initial mass function from high-mass peaked to low-mass peaked one at [Fe/H] ~ -2 in the viewpoint of the distribution of carbon abundance and the frequency of carbon-enhanced stars. From the observed small scatters of abundances for alpha-elements and iron-group elements , it is suggested that the chemical enrichment of our Galaxy takes place in a well-mixed interstellar medium. The abundance trends of alpha-elements are highly correlated with each other including alpha-enhanced and depleted stars, while the abundances of iron-group elements are subject to different slopes relative to the iron abundance. This implies that the supernova yields of alpha-elements are almost independent of mass and metallicity, while those of iron-group elements have a metallicity dependence or mass dependence with the variable initial mass function.

Polarimetry of Earthshine as a Test of Ocean Detection on Exoplanets

Jun TAKAHASHI, Yoichi ITOH, Takahiro NIWA,
Yusuke HIROWATARI

We present our ongoing work on polarimetry of Earthshine on the Moon. Polarimetry of extrasolar planets is anticipated as a possible method of detection of an ocean surface on planets. Theoretical models estimate that specular reflection on smooth liquid surface will cause a great polarized fraction in the total reflected light from the planet. This may cause a detectable difference in polarized fraction between "ocean planet" and "land planets". This work is intended to evaluate feasibility of ocean detection on extrasolar planets through polarimetry. We have been conducting observations with Simultaneous Imaging/Spectroscopic Polarimeter installed on 60 cm telescope at Nishi-Harima Astronomical Observatory in Japan. Japan is located between a vast ocean and a vast continent. Earthshine on the waxing Moon observed from Japan is originated from a continent-dominant surface on the Earth, while that on the waning Moon is from an ocean-dominant surface. Thus we can compare between polarization from continent-dominant surface and that from ocean-dominant surface by observing earthshine on both the waxing and waning Moon. Up to the present we have obtained 6 data: 4 for the waxing Moon and 2 for the waning Moon. The observed wavelength was 551 nm (V band). We have derived polarization phase curves for each of the waxing and waning Moon. We will show and discuss them on the poster.

Dry Minor Mergers and Size Evolution of early-type galaxies in High Density Environments

Taira Oogi[1] and Asao Habe[2]

[1]*Department of Cosmosciences, Graduate School of Science, Hokkaido University, Japan*

[2]*School of Science, Graduate School of Science, Hokkaido University, Japan*

Recently, several observations imply that high-z ($z \sim 2-3$) galaxies are quite compact than that with comparable mass at $z \sim 0$. Since there is direct observational evidence for a substantial number of 'dry' mergers between early-type galaxies in an intermediate redshift galaxy cluster, we simulate dry major and minor mergers between early-type galaxies with N-body simulations that nal remnant masses are same. Simulated early-type galaxies are composed of stellar bulge and dark matter halo components, and their densities are extremely high as seen in high-z compact massive galaxies. We compare the remnant properties, especially their sizes. We show that the minor mergers cause the size growth by a factor of at least ~ 4 in the case of mass growth by a factor of 2, while the size increases by a factor of ~ 2 in the major merger case. We also simulate minor mergers by relatively lower density satellites, and we nd that these mergers decrease velocity dispersion of the compact massive, high density galaxy than by higher density satellites. This implies that dry minor mergers are more e ective process in size evolution of early-type galaxies. Furthermore we analyze the cosmological N-body simulation, the Millennium Simulation, to extract merger histories of high-z massive galaxies in high density environments. We select these galaxies with the following criteria, (1) dark matter haloes are in rich clusters at $z = 0$, and (2) these haloes are already more massive than $10^{12}M_{\odot}$ in $z \sim 2$. We nd that in the merger histories from $z \sim 2$ to $z = 0$, minor mergers are more dominant than major ones, and the galaxies experience suf- cient amounts of minor mergers to induce the size evolution to local elliptical galaxies. Our result supports the scenario that high-z compact massive galaxies experience size evolution via dry minor mergers and become member elliptical galaxies of rich clusters at $z = 0$.

The Relation between the Stellar Structure of Red Giants and the Formation and Evolution of Gas Giant Planets

KAZUHIRO KANAGAWA
Department of Cosmosciences, Graduate School of Science, Hokkaido University, Sapporo, 060-0810,Japan

Equilibria and evolution of gravitating systems that consist of multi-components often appear in astrophysical problems. Especially, the behavior of two components gravitating systems with a core component at center and an envelope component extending around the core component, so-called core-halo structure, is important and can be applied in many astrophysical problems, such as formation and evolution of globular clusters or the clusters of galaxies. The typical example of core-halo structure is stellar structure of red giant phase. Such stellar structure can be well described by a double-polytrope model (Fujimoto &Tomisaka 1992). This model shows why red giant star has an structure expanding more than the main sequence stars of equivalent parameters.

In this study, we apply the double polytrope model to the formation and evolution of gas giant planets because they also have the core-halo structure. According to core accretion scenario, gas giant planets, such as Jupiter or Saturn, are formed by gas capture by the solid core which are formed through collision and merging of planetesimals. Planets formed in such a way have a structure which is composed of a solid core made of rock or ice and a gaseous envelope around rocky or icy core. This structure should be resembled red giant star.

As for the gas giant planets, it is known that if a planet has more massive core than a critical value, it causes a runaway accretion of gas onto the planets to form gas giant planets with gaseous massive envelope (Mizuno 1980; Bodenheimer & Pollack 1986). On the other hand, the double polytrope changes the structural behavior according to the mass ratio between the fore and envelope; if the core is more massive than the envelope, the envelope structure is determined by the externally by the gravity of the core and expands as the mass of envelope increases, while otherwise, the envelope structure is dominated by the self-gravity and shrinks in radius as the envelope mass increases. In the poster, I discuss about the structure in common between red giant star and gas giant, and in particular, the relationship of the thermal nature of latter and the runaway accretion of gas giant planets.

Astronomy & Astrophysics manuscript no. 15137
June 28, 2010

Lithium depletion in solar-like stars: no planet connection

Patrick Baumann[1], Iván Ramírez[1], Jorge Meléndez[2], Martin Asplund[1], and Karin Lind[3]

[1] Max Planck Institute for Astrophysics, Postfach 1317, 85741 Garching, Germany
e-mail: pbaumann, ivan, asplund@mpa-garching.mpg.de
[2] Centro de Astrofisica da Universidade do Porto, Rua das Estrelas, 4150-762 Porto, Portugal
e-mail: jorge@astro.up.pt
[3] European Southern Observatory(ESO), Karl-Schwarzschild-Str. 2, 85748 Garching, Germany
e-mail: klind@eso.org

Received ...; accepted ...

ABSTRACT

We have determined precise stellar parameters and lithium abundances in a sample of 117 stars with basic properties very similar to the Sun. This sample selection reduces biasing effects and systematic errors in the analysis. We estimate the ages of our sample stars mainly from isochrone fitting but also from measurements of rotation period and X-ray luminosity and test the connection between lithium abundance, age, and stellar parameters. We find strong evidence for increasing lithium depletion with age. Our sample includes 14 stars that are known to host planets and it does not support recent claims that planet-host stars have experienced more lithium depletion than stars without planets. We find the solar lithium abundance normal for a star of its age, mass, and metallicity. Furthermore, we analyze published data for 82 stars that were reported to support an enhanced lithium depletion in planet hosts. We show that those stars in fact follow an age trend very similar to that found with our sample and that the presence of giant planets is not related to low lithium abundances. Finally, we discuss the systematic biases that led to the incorrect conclusion of an enhanced lithium depletion in planet-host stars.

Key words. Sun: abundances – stars: abundances – stars: planetary systems

1. Introduction

The lithium abundances of solar-like stars in the solar neighborhood spread over more than two orders of magnitude, which is much larger than the range of abundances seen for other elements (e.g., Reddy et al. 2003). The Sun, in particular, has a very low lithium abundance compared to many nearby solar analogs (e.g., Lambert & Reddy 2004). Furthermore, the photospheric solar lithium abundance is about 160 times lower than that measured in meteorites ($\log \epsilon_{\mathrm{Li},\odot} = 1.05 \pm 0.10$ dex[1], $\log \epsilon_{\mathrm{Li,met}} = 3.26 \pm 0.05$ dex; both values are from Asplund et al. 2009). This difference between the current solar and protosolar values is not predicted by standard stellar evolution models (e.g., D'Antona & Mazzitelli 1984).

The wide range of observed lithium abundances in nearby solar-like stars is most likely due to a dependency between $\log \epsilon_{\mathrm{Li}}$ and the star's age and mass (e.g., Montalbán & Schatzman 2000; Charbonnel & Talon 2005; Xiong & Deng 2009; Do Nascimento et al. 2009). Lithium is easily destroyed by proton capture reactions in stellar interiors. Thus, if lithium is transported between the chemically mixed outer convection zone and deeper lying regions with temperatures that are high enough for lithium destruction, the photospheric abundance will decrease with time. Diffusion probably contributes to the lowering of the surface lithium abundance throughout the main-sequence stage. This would explain why the photospheric solar abundance is much smaller than the meteoritic one. We expect an enhanced lithium depletion in stars with larger convection zones on the main sequence as well as in stars with a higher degree of differential rotation between the radiative core and the convective envelope (see below). The reason is that lithium is only depleted as it moves to deeper and therefore hotter regions of a star, where the temperature is high enough (about 2.5 million K) for proton capture (see, e.g., Pinsonneault 1997).

Recently, it has been suggested that the presence of planets around a star could affect the evolution of the photospheric lithium abundance (e.g., Bouvier 2008). A long-lasting star-disk interaction during the star's pre-main sequence phase could slow down the host-star's rotation and therefore increase the degree of differential rotation between the star's core and envelope. Rotationally-driven mixing is then enhanced, thus destroying more lithium than in stars without planets because fast rotators evolve with little core-envelope decoupling. Planet migration affects the star's angular momentum, which might also have an impact on $\log \epsilon_{\mathrm{Li}}$. Finally, the ingestion of a planet can increase the surface lithium abundance (e.g., Montalbán & Rebolo 2002; Israelian et al. 2001).

The possibility of a lithium-planet connection is subject of ongoing discussions. Recent work by Gonzalez (2008), Gonzalez et al. (2010), Castro et al. (2008), and Israelian et al. (2009) suggests a possible $\log \epsilon_{\mathrm{Li}}$-planet dependency, whereas Ryan (2000) and Luck & Heiter (2006) find that stars with planets show the same lithium distribution as the comparison field stars. Takeda et al. (2007, 2010) describe the stellar angular momentum as the crucial factor that determines the lithium abundance of solar-like stars and find that slow rotators show an enhanced lithium depletion. Planets *could* be the reason for a slow rotation, but they were not able to draw firm conclusions due to

[1] We use the standard notation $\log \epsilon_{\mathrm{X}} = \log \frac{n_{\mathrm{X}}}{n_{\mathrm{H}}} + 12$, where n_{X} and n_{H} are the the number densities of element X and hydrogen, respectively. Also, for metallicities we use the common abbreviation [Fe/H]= $\log \epsilon_{\mathrm{Fe}} - \log \epsilon_{\mathrm{Fe}}^{\odot}$.

Sebastien Salmon

Title: How asteroseismology can help to precisely constrain properties of planet-host stars.

Abstract: Nowadays more and more exoplanets are discovered, about 500, and are mainly studied by radial velocity and transit measurements. Precise knowledge on their characteristics is crucial to develop theories of planetary formation and evolution. In that aim, not only the masses of the planet(s) and of the star but also the evolutionary stage of the system must be derived. From radial velocity measurements one has to assume the inclination and the stellar mass of the system to disentangle the mass of the planet. When transit is observable, one can measure the ratio of planetary and stellar radii. Finally, the stage of evolution of the system is determined by the one of the star. Thus the host star must be well known to obtain a full set of values on the system properties. However, determination of stellar parameters such as the mass, radius and stage of evolution from classical observables (Teff, log g, [Fe/H]) suffers of large uncertainties. This is particularly true for dwarf stars on the Main Sequence. Fortunately we can obtain better constrains with help of asteroseismology. That latter approach probes the stellar properties through the observations of oscillations present in stars. With the launches of high-precision photometry space missions, CoRoT and Kepler, we are now able to detect oscillations in a huge number of stars. In particular Kepler photometry, primarily intended to detect transits of planets, can give accurate stellar parameters of planetary systems as it also affords to make asteroseismology of stars. We propose to make here a review of different applications of asteroseismology that have already been done on stars hosting planets.

Global oscillation modes in the evolving disk of B emission stars

Finny Oktariani

Abstract

B emission stars (or Be stars) are a non-supergiant B-type stars whose spectra show one or more Balmer lines in emission. These emission lines arise from an equatorial disk around the star. The central star is considered a massive star rotating near critically. When the star ejects mass from an equatorial surface, a decretion disk forms, where the material drifts outward, not inward, by the effect of viscosity. Decretion disks share many characteristics with accretion disks. Kato (1983) showed that in a nearly Keplerian accretion disk, a one-armed mode shows up as a very slowly revolving perturbation pattern. In decretion disks, the line profile variability caused by the precession of this mode is called a long-term V/R variation, where V and R stands for the violet (V) to red (R) peak intensities of a double-peaked emission line profile, respectively. Studying the one-armed modes is important in order to understand this phenomenon.

In this paper, we study the global one-armed oscillation modes in Be disks, taking account of the effect of the disk evolution (dissipation and re-formation). First, we calculate the density evolution in decretion disks. To model the disk formation stage, we inject mass at a radius just outside the star. As the disk grows, the frequencies of global one-armed modes increase toward asymptotic values. Then, we turn off the mass injection to model the disk in the dissipation stage. The one-armed modes in the disk dissipation stage have significantly higher frequencies than those in the disk formation stage.

Probing the atmosphere of the 'hot jupiter' TrES-1b with HST

Aude Alapini, Frédéric Pont & David Sing
University of Exeter, Stocker Road, Exeter, EX44QL, UK

The structure and chemical composition of the atmosphere of transiting exoplanets can be studied using transmission spectroscopy. The radius of a transiting planet varies with wavelength due to the chemistry of its different atmospheric layers. This work reviews the HST transit observations (5000 – 10000 Å) of the hot gas giant exoplanet TrES-1b. The atmosphere of this planet is analysed, comparing the observed transmission spectrum to synthetic model spectra.

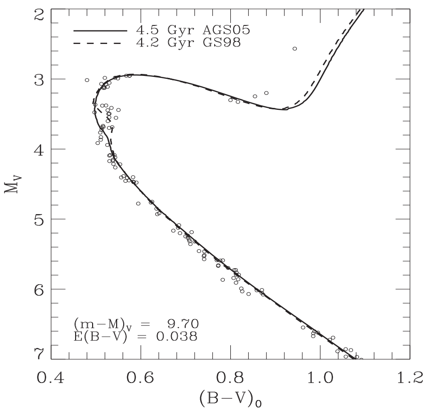
Contact: alapini@astro.ex.ac.uk

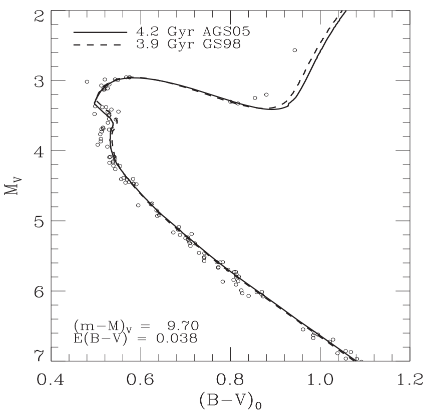
On Using the Color-Magnitude Diagram Morphology of M67 to Test Solar Abundances

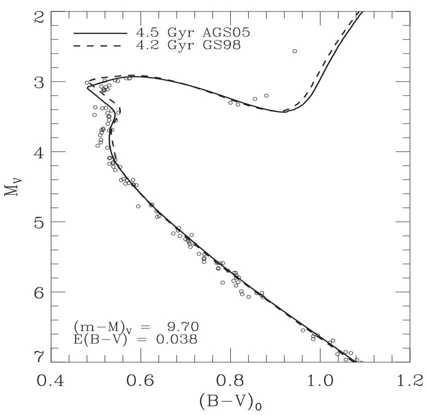
Zazralt Magic

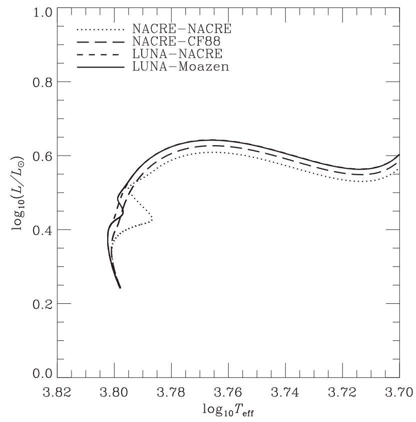
Abstract

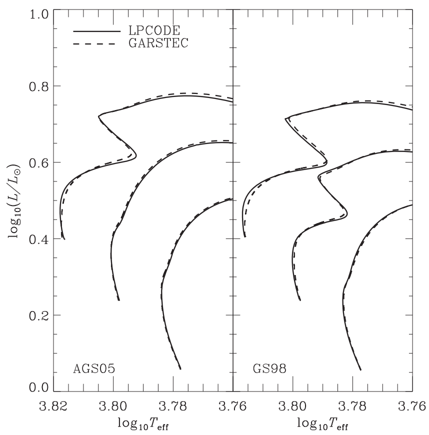
The open cluster M67 has solar metallicity and an age of about 4 Gyr. The morphology of the color-magnitude diagram (CMD) of M67 around the turnoff (TO) shows a clear hook-like feature, a direct sign that stars close to the TO have convective cores. VandenBerg et al. investigated the possibility of using the morphology of the M67 TO to put constraints on the solar metallicity, particularly CNO-elements, for which solar abundances have been revised downward by more than 30% over the last few years. Here, we extend their work, filling the gaps in their analysis. To this aim, we compute isochrones appropriate for M67 using new (low metallicity) and old (high metallicity) solar abundances and study whether the characteristic TO of M67 can be reproduced or not. We also study the importance of other constitutive physics on determining the presence of such a hook, particularly element diffusion, overshooting and nuclear reaction rates. We find that using the new solar abundance makes it more difficult to reproduce M67. This result is in agreement with results by VandenBerg et al. However, changes in the constitutive physics of the models, particularly overshooting, can influence and alter this result to the extent that isochrones constructed with models using low CNO solar abundances can also reproduce the TO morphology in M67. We conclude that only if all factors affecting the TO morphology are completely under control (and this is not the case), M67 could be used to put constraints on solar abundances.

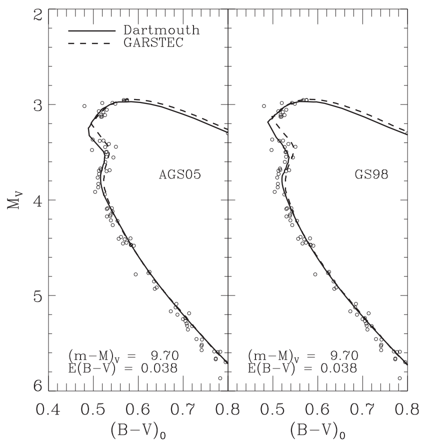












Kohei Inayoshi

We consider primordial gas clouds in dark matter halos with virial temperature of $\sim 10^4$K, irradiated with strong FUV radiation. When H_2 formation is suppressed by photodissociation process, the temperature of clouds adiabatically rises until 8000K, where the H atomic cooling (e.g. Lyα emission) begin to be an effective agent. The clouds collapsing isothermally by atomic cooling are able to avoid fragmentation, form supermassive stars (SMSs), and collapse into supermassive black holes (SMBHs) with a mass of $\sim 10^6 M_\odot$. The rapid formation of SMBHs is expected to be an important pathway for the formation of SMBHs with a mass of $\sim 10^9 M_\odot$ in the early universe ($z \simeq 6$).

However, since the strong FUV radiation is required to suppress the H_2 formation, it is significant to investigate whether the scenario is realizable in the early universe. The strong FUV sources, i.e., large galaxies, contain a large number of massive stars and some mini-quasars. Such large galaxies is also expected to emit strong cosmic rays (CRs) or X-ray radiation ($2 - 10$keV), which ionize the gas clouds and promote the H_2 production. Therefore, if CRs and X-ray present, the critical intensity, $J_{\rm crit}$ required to suppress the H_2 cooling increases.

Here, we investigate the ionization effects of CRs and X-ray on the evolution of the clouds irradiated by strong FUV radiation. Then, we find the dependence of the critical intensity on the amounts of CRs and X-ray photons. By this way, we discuss the nature of FUV sources needed to induced SMSs formation and explore the possibility of such a scenario about SMBHs formation.

Gas Accretion onto Circum-Planetary Disks

Tanigawa Takayuki[1,2], Machida Masahiro[3], and Ohtsuki Keiji[1,4]

[1]Center for Planetary Science, [2]Institute of Low Temperature Science, Hokkaido University, [3]National Astronomical Observatory of Japan, [4]Faculty of Science, Kobe University

Satellite systems around giant planets are commonly observed. Most of the large satellites are categorized into regular satellites, which rotates on nearly circular and co-planar circular orbits. Because of the orbital properties, they are thought to be formed in circum-planetary disks, which are natural by-product in the course of giant planet formation, and which doesn't exist around the current giant planets of our solar system.

The disk structure is decisively important for the formation process of the satellite systems, however the structure and formation process of the disks are poorly known.

In this study, we investigated gas accretion flow onto circum-planetary disks in order to understand the structure and formation process of circum-planetary disks. We found that gas accretion occurred in a manner that gas fell onto the disk surface from midair that were originated from off-mid-plane gas in proto-planetary disks. We also found that the mass flux onto the circum-planetary disks are well described by power-law function of distance from the planets, which would be useful in order to model circum-planetary disk structure and formation process of satellite systems.

Title:

Search for unknown exoplanets by detection of transit timing variations

Author:

Sho Manabe (Presenter), Yoichi Itoh

Abstract:

The exoplanets of about 500 have been detected up to the present time. And, those majorities are gas-giant planets. Here, we are interested in the search for terrestrial planets.

In fact, known exoplants of about 90% have been detected by the radial velocity (RV) method. However, if our sun is observed from the outside of the solar system by the RV method, planets that is lighter than the Jupiter and the Saturn will not be detected for the detection limit of the RV method. To detect these plantes lighter than the Jupiter and the Saturn, that is undetectable terrestrial exoplanets in other planetary systems, we should use another observation method.

We have made observations by the transit timing variation (TTV) method. In the TTV method, there is potency to detect lighter exoplanets than the RV method. It is forecast that the transit periods of known transit planets will not be constant, if there are additional planets in the already known transit planetary systems. Therefore, we can detect additional planets, by making many transit observations and by detecting the transit timing variations.

In our poster presentation, we will make a presentation about the results of our TTV observations up to this time.

Evolution of Zn,Co and Ba Enrichment of EMP Stars in the Framework of Hieratical Structure Formation

Shimako Yamada

IMF is one of the important ingredients on the formation and evolution of galaxies. Komiya et al.(2007) deduced that extremely metal poor(EMP) stars had a high-mass IMF with the median mass of 5-20Mo from the statistics of carbon enhanced EMP stars This indicates there should be a changeover of the IMF from the high-mass to the low-mass one such as observed for the spheroid components and thick disc somewhere at the in-between metallicity. On the other hand, the recent the large-scaled spectroscopy have unveiled the surface abundances for many EMP stars. The Stellar Abundances for Galactic Archaeology(SAGA) database(Suda et al.2008) compiles almost all these abundance data, which enables us the statistical analysis of the characteristics of abundaces of EMP stars. The purpose of this work is to seek for the imprints that the changeover of IMF have left in the surface abundance of elements among the sample stars of SAGA database. In this work we choose as Zn, Co and Ba as the target elements for the purpose. We find that mean abundance ratios of [(Zn,Co,Ba)/Fe] show significant breaks around [Fe/H] -2 which consistent with the imprints that the changeover of IMF predicted from the statistics of carbon enrichment around it (Suda et al. 2010). Since the variations of supernova yields result from the mass dependence of yields when the IMF changes, we may give insights into the mass dependence of supernova yields and discuss constraints on the production sites for Zn, Co and Ba.

Weak-field dynamo emerging in a rotating spherical shell with stress-free top and no-slip bottom boundaries

Youhei Sasaki*, Department of Mathematics, Kyoto University, Japan
Shin-ichi Takehiro, Research Institute for Mathematical Sciences, Kyoto University, Japan
Yoshi-Yuki Hayashi, Department of Earth and Planetary Science, Kobe University, Japan
Kiyoshi Kuramoto, Department of Cosmoscience, Hokkaido University, Japan
*Email:uwabami@gfd-dennou.org

According to the recent progress of computer resources, three-dimensional numerical simulations of MHD dynamo in rotating spherical shells have been carried out vigorously in order to investigate generation and maintenance mechanisms of magnetic field in celestial bodies. Most of the simulations performed so far use both stress-free or both no-slip conditions at the top and bottom boundaries. However, it seems that the no-slip condition at the bottom boundary and the stress-free condition at the top boundary are suitable for the gas giant interiors, the solar convection zone whose internal structure is revealed by recent helio-seismological observations, and the earth's outer core whose top layer may be stably stratified.

Under these backgrounds, we have carried out numerical experiments of MHD dynamo in a rotating spherical shell with two kinds of mechanical boundary conditions. One is both no-slip boundary conditions, the other is the stress-free condition at the top and the no-slip condition at the bottom. The Ekman number, the Prandtl number, and the ratio of inner and outer radii are fixed to 10^{-3}, 1, 0.35, respectively. The magnetic Prandtl number is varied from 5 to 50, and the modified Rayleigh number is increased from 1.5 to 10 times critical. For each combination of the parameters and the boundary conditions, time integration of non-magnetic thermal convection is carried out until a quasi-steady state is established. Starting from this quasi-steady state with a small dipole magnetic field, MHD dynamo calculation is performed.

For the cases of both no-slip boundary condition, we obtained alpha-squared type dynamo solutions, which is similar to those obtained by the previous studies. In these dynamo solutions, the magnetic energy is larger than the kinetic energy. On the other hand, for the cases of the stress-free top boundary condition, we obtained dynamo solutions where the magnetic energy is far less than the kinetic energy. These dynamo solutions are characterized by the two-layer spatial structure. The upper layer is governed by prograde strong zonal flows and less-organized prograde propagating spiral convection vortices, while the lower layer is dominated by turbulent retrograde propagating columnar convection vortices. The strong zonal flow in the upper layer prevents the magnetic field generated in the lower layer from penetrating to the surface of the spherical shell.

In order to examine generation and maintenance mechanisms of the magnetic field in these weak-field dynamo solutions, we obtained time-averaged fields on the longitudinally moving coordinate travelling with the same speed as the convection vortices in the upper or the lower layers, and succeeded in extracting typical convective and magnetic structures in the upper and lower layers, respectively. Further, we analyzed kinetic and magnetic energy budget of the dynamo solution, and clarified energy transfer between the toroidal and poloidal components of the kinetic and magnetic energies. Together with these analyses, we identified the regions where conversions from the poloidal and toroidal kinetic energies to the poloidal and toroidal magnetic energies, respectively. In the lower layer of the spherical shell, whirlpool poloidal fields are generated from toroidal fields by the helical poloidal convective vortices through the magnetic field line stretching. These whirlpool magnetic field lines are brought up by the convective motion in the lower layer and they penetrate to the upper layer intermittently. These magnetic field lines are caught by the toroidal spiral vortices in the upper layer and toroidal magnetic fields are generated. These toroidal fields fall down into the lower layer intermittently, and are caught by the convective vortices, and whirlpool poloidal field generation occurs again. The self-sustained magnetic field is generated by repeating these processes.

High Mass X-ray Binaries in the NIR: Orbital solutions of two highly obscured systems. *

Andrew Mason[1]†, Andrew Norton[1] , Simon Clark[1],
P. Roche[1], Ignacio Negueruela[2]

[1] The Open University, Milton Keynes, UK
[2] Departamento de Física, Universidad de Alicante, Alicante, Spain

Abstract: The maximum mass of a neutron star is poorly defined. Theoretical attempts to define this mass have thus far been unsuccessful. Observational results currently provide the only means of narrowing this mass range down. Eclipsing X-ray binary (XRB) pulsar systems are the only interacting binaries in which the mass of the neutron star may be measured directly. Only 10 such systems are known to exist, 6 of which have yielded NS masses in the range 1.06 1.86 $M_\odot$. We present the first orbital solutions of two such eclipsing systems, OAO 1657-415 and EXO 1722-363, whose donor stars have only recently been identified. Using observations obtained using the VLT/ISAAC NIR spectrograph, our initial work was concerned with providing an accurate spectral classification of the two counterpart stars, leading to a consistent explanation of the mechanism for spin period evolution of OAO 1657-415. Calculating radial velocities allowed orbital solutions for both systems to be computed. These are the first accurate determinations of the NS and counterpart masses in XRB pulsar systems to be made employing NIR spectroscopy.

*Based on observations carried out at the European Southern Observatory under programmes 081.D-0073(A), 077.B-0872(A) and 081.D-0073(B).

†a.mason@open.ac.uk

Interior structure models of solar and extrasolar giant planets

N. Nettelmann, J.J. Fortney, U. Kramm, R. Redmer

The composition and structure of giant planets gives indications on the process of planet formation and the physical conditions of the protostellar disk where they formed from. We present interior models and thermal evolution models of giant gas planets (Jupiter), icy planets (Uranus, Neptune, GJ436b), and of the super-Earth GJ1214b. We investigate what we currently know about these planets in terms of core mass and metallicity, and discuss what would need to know in order to better constrain the models. In particular, we find that Jupiter has a small rock core of at most 5 Earth masses but is highly enriched in metals in its deep interior; Uranus and Neptune might be similar in composition but Uranus' low heat flow remains an unsolved riddle; GJ436b and GJ1214b do not contain water in an ice phase, but possibly water plasma, or be dry planets with shallow H/He atmosphere.

A correlation between the metallicity of planets and their host stars

N. Miller[1], and *J. J. ~Fortney*[1]
[1]Department of Astronomy and Astrophysics, University of California, Santa Cruz
(neil@astro.ucsc.edu, jfortney@ucolick.org)

Planet Transit observations have revealed a population of Hot Jupiters with unexpectedly large radii. This yet undetermined physical mechanism seems to be correlated with the average stellar incident flux upon the planet. Transit observations combined with radial velocity data tell us about the mass and densities of these planets, which in principle constrain the composition. However, for the large-radius planets the composition is difficult to determine because putting energy into the planet counteracts the effects of heavy elements (``metals''), which would otherwise shrink a planet.

Fortunately, a sample of transiting planets is now emerging at larger orbital distances and smaller incident fluxes that seem to be essentially unaffected by this heating mechanism. In this work we determine the interior heavy element mass for this population of less irradiated transiting planets. There is a correlation between the stellar metallicity and the mass of heavy elements in its transiting planet. It appears all giant planets posses a minimum of ~10-15 Earth masses of heavy elements, with planets around metal-rich stars being more metal-enriched. This relationship may provide a constraint on planet formation and evolution models.

A crab of their flocks, a flock constructed by crabs

Tetsuya Matsui

Animals that create herd, flock, or school are seemed to recognize other member to decide what rules they must be obeyed. That rules are factors of forming and maintaining their flocks. Mictyris brevidactylus is known to form large flocks on beach and they work forward and go underground to avoid from enemies together. And their sight is developed so they probably can recognize other members. In this paper, we assumed that Mictyris brevidactylus have a tendency to be attracted to more large and like a lump group and inspect it. We used two equipments to experiment on crabs, and used two ways to reenact large and less an opening flocks. At first we experimented with several sizes vinyl tubes and put each members of crabs into them to let crabs see as flocks of having several sizes openings. Secondly we used cosmetic mirrors to magnify their images more than real images. And we compared magnified mirror images with flocks formed from several individuals. As s result, crabs were attracted to more large and less opening flocks. But when the ration was more than five the remarkable differentials cleared they did not select larger sides. From this result soldier crabs are usually invited more large flocks but they aren't invited relative large flocks. So they don't form extremely large flocks. And I suggested new calculating system, crab automaton.

The Fraction of Stars Hosting Hot Jupiters

Bayliss Daniel

Abstract. The frequency of Hot Jupiters around Galactic dwarf stars is determined from the results of the SuperLupus transit survey and realistic Monte Carlo simulations of the survey efficiency. We find that for Hot Jupiters with mean radii of $1.1R_J$ and periods between 1 and 10 days, the frequency around dwarf stars is just $0.16\pm^{0.6}_{0.2}\%$.

Theoretical instability strip of the upper part of the HR diagram

M. Godart et al.

Massive stars (larger than $9M_{\odot}$) are characterized by a large radiation over gaz pressure ratio and a large temperature over density ratio. With increasing initial mass, they suffer stronger stellar winds which plays an important role in the chemical enrichment of the galaxies; the induced mass loss affects also their evolution and their internal structure on the main sequence (MS) and on the post-main sequence (post-MS). Recent ground-based observations and space missions have shown the presence of pulsations in massive stars, such as accouctic and gravity modes excited by the κ-mechanism and even solar-like oscillations. Strange modes are also found to be excited in the most massive stars. We present here κ-mechanism instability domains for the upper HR diagram both for the MS and the post-MS. For the post-MS an intermediate convective zone is needed to excite modes. We compute evolutionary tracks and non-adiabatic frequencies for different input parameters such as the metallicity, the mass loss rate and the overshooting parameter.

Neutron-capture and the r-process

K. Otsuki
Faculty of Science, Fukuoka University kotsuki@fukuoka-u.ac.jp
S. Typel, G. Martinez-Pinedo, K. Langanke
GSI, Germany

R-process is a rapid neutron-capture process which formed about a half of elements heavier than iron in the nature. This process occurs on explosive event such as Type II supernovae, but nobody has been identified its astrophysical origin unambiguously.
Neutron capture reaction consists of two component, compound process and direct-capture process. The direct capture reactions are neglected in most of previous r-process studies although it has been pointed out that direct capture reaction become dominant around r-process path.
We studied a role of direct capture reaction in the r-process using dynamical network code. The direct capture makes freeze out earlier and changes final abundances drastically because neutron-capture reaction rates change the physical condition of freeze out. Systematic studies of neutron-capture reaction rates, based on experiments and theory are strongly desired.

Hiroko Ito

TItle: Lithium abundances of the most metal-poor turnoff stars

Abstract:

Among metal-poor turnoff stars, Li abundance appears to be constant regardless of metallicity, A(Li)=log(Li/H)+12=2.2, which is called "Spite plateau" (Spite & Spite 1982). Metal-poor turnoff stars were conventionally assumed to preserve their initial Li abundances in the atmospheres because of the shallow surface convection zones. However, there is a discrepancy between the observed Spite plateau and the primordial Li abundance inferred from standard Big Bang nucleosynthesis (SBBN) models adopting the baryon density determined from observations of the cosmic microwave background (CMB) by the WMAP satellite, A(Li)=2.72 (Cyburt et al. 2008). The discrepancy, so-called "lithium problem", is one of the biggest mysteries in astronomy and cosmology that are not yet to be solved.

In observational approaches to the lithium problem, it is important to inspect the Li abundance behavior in the lowest metallicity range ([Fe/H]<-3.5). In this range, intensive study on Li abundance has yet to be done due to the lack of good targets. However, thanks to the massive spectroscopic surveys as well as our Subaru intensive program (Aoki et al.), we measured Li abundances of 9, newly discovered turnoff stars. Most of them are found to lie at [Fe/H]<-3.0, and 5 of them at [Fe/H]<-3.5. For most of the targets are derived comparable Li abundances with the Spite plateau (A(Li)=2.0-2.3), but a relatively low value is derived for the most metal-poor target (A(Li)=1.8, [Fe/H]=-3.9).

Nucleosynthesis in High-Entropy Hot-Bubbles of SNe and Abundance Patterns of Extremely Metal-Poor Stars

Natsuko Izutani[1] and Hideyuki Umeda[1]

[1] *Department of Astronomy, School of Science, University of Tokyo, Hongo, Tokyo 113-0033, Japan*

izutani@astron.s.u-tokyo.ac.jp; umeda@astron.s.u-tokyo.ac.jp

Accepted to ApJL: July 21, 2010

ABSTRACT

There have been suggestions that the abundance of Extremely Metal-Poor (EMP) stars can be reproduced by Hypernovae (HNe), not by normal supernovae (SNe). However, recently it was also suggested that if the innermost neutron-rich or proton-rich matter is ejected, the abundance patterns of ejected matter are changed, and normal SNe may also reproduce the observations of EMP stars. In this letter, we calculate explosive nucleosynthesis with various $Y_{\rm e}$ and entropy, and investigate whether normal SNe with this innermost matter, which we call "hot-bubble" component, can reproduce the abundance of EMP stars. We find that neutron-rich ($Y_{\rm e}$ = 0.45-0.49) and proton-rich ($Y_{\rm e}$ = 0.51-0.55) matter can increase Zn/Fe and Co/Fe ratios as observed, but tend to overproduce other Fe-peak elements.

In addition to it, we find that if slightly proton-rich matter with $0.50 \leq Y_{\rm e} < 0.501$ with $s/k_{\rm b} \sim$ 15-40 is ejected as much as $\sim 0.06\ M_{\odot}$, even normal SNe can reproduce the abundance of EMP stars, though it requires fine-tuning of $Y_{\rm e}$. On the other hand, HNe can more easily reproduce the observations of EMP stars without fine-tuning. Our results imply that HNe are the most possible origin of the abundance pattern of EMP stars.

Subject headings: nuclear reactions, nucleosynthesis, abundances - supernovae: general

1. Introduction

The observational trends of extremely metal-poor (EMP) stars reflect SN nucleosynthesis of Population (Pop) III, or almost metal-free stars. Their observed abundances show