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Editors: Jacco van Loon and Albert Zijlstra

Editorial

Dear Colleagues,

It is our pleasure to present you the 124$^{\rm th}$ issue of the AGB Newsletter, with 25 refereed journal articles, numerous conference papers and two job opportunities in Hong Kong. This issue covers AGB-related research in an especially diverse range of stellar systems: the Milky Way disc and halo, ω Centauri, the Magellanic Clouds, other Local Group dwarf galaxies Fornax, Sgr dIrr, DDO 210 and NGC 3109, to as far as the $z = 0.0237$ Scd galaxy IC 1277. We also wish to draw your attention in particular to the review paper on AGB nucleosynthesis by Amanda Karakas and John Lattanzio.

The next issue will be distributed on the 1$^{\rm st}$ of November; the deadline for contributions is the 31$^{\rm st}$ of October.

Editorially Yours,
Jacco van Loon and Albert Zijlstra

Food for Thought

This month's thought-provoking statement is:

Mixing is the least well understood physical phenomenon inside red giants

Reactions to this statement or suggestions for next month's statement can be e-mailed to agbnews@astro.keele.ac.uk (please state whether you wish to remain anonymous)

Refereed Journal Papers

Stellar Evolutionary Effects on the Abundances of PAH and SN-Condensed Dust in Galaxies

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Spectral and photometric observations of nearby galaxies show a correlation between the strength of their mid-IR aromatic features, attributed to PAH molecules, and their metal abundance, leading to a deficiency of these features in low-metallicity galaxies. In this paper, we suggest that the observed correlation represents a trend of PAH abundance with galactic age, reflecting the delayed injection of carbon dust into the ISM by AGB stars in the final post-AGB phase of their evolution. AGB stars are the primary sources of PAHs and carbon dust in galaxies, and recycle their ejecta back to the interstellar medium only after a few hundred million years of evolution on the main sequence. In contrast, more massive stars that explode as Type II supernovae inject their metals and dust almost instantaneously after their formation. We first determined the PAH abundance in galaxies by constructing detailed models of UV-to-radio SED of galaxies that estimate the contribution of dust in PAH-free H II regions, and PAHs and dust from photodissociation regions, to the IR emission. All model components: the galaxies' stellar content, properties of their H II regions, and their ionizing and non-ionizing radiation fields and dust abundances, are constrained by their observed multiwavelength spectrum. After determining the PAH and dust abundances in 35 nearby galaxies using our SED model, we use a chemical evolution model to show that the delayed injection of carbon dust by AGB stars provides a natural explanation to the dependence of the PAH content in galaxies with metallicity. We also show that larger dust particles giving rise to the far-IR emission follow a distinct evolutionary trend closely related to the injection of dust by massive stars into the ISM.

Submitted to ApJ
Available from arXiv:0708.0790

The variable mass loss of the AGB star WX Psc as traced by the CO $J = 1-0$ through $7-6$ lines and the dust emission.

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Low and intermediate mass stars lose a significant fraction of their mass through a dust-driven wind during the Asymptotic Giant Branch (AGB) phase. Recent studies show that winds from late-type stars are far from being smooth. Mass-loss variations occur on different time scales, from years to tens of thousands of years. The variations appear to be particularly prominent towards the end of the AGB evolution. The occurrence, amplitude and time scale of these variations are still not well understood.
The goal of our study is to gain insight into the structure of the circumstellar envelope (CSE) of WX Psc and map the possible variability of the late-AGB mass-loss phenomenon.
We have performed an in-depth analysis of the extreme infrared AGB star WX Psc by modeling *(1)* the CO $J = 1-0$ through $7-6$ rotational line profiles *and* the full spectral energy distribution (SED) ranging from 0.7 to 1300 μm. We hence are able to trace a geometrically extended region of the CSE.
Both mass-loss diagnostics bear evidence of the occurrence of *mass-loss modulations* during the last $\sim$2000 yr. In particular, WX Psc went through a high mass-loss phase ($\dot{M} \sim 5\,10^{-5}$ M$_\odot$ yr^{-1}) some 800 yr ago. This phase lasted

about 600 yr and was followed by a long period of low mass loss ($\dot{M} \sim 5\,10^{-8}$ $M_\odot$ yr^{-1}). The present day mass-loss rate is estimated to be $\sim 6\,10^{-6}$ $M_\odot$ yr^{-1}.
The AGB star WX Psc has undergone strong mass-loss rate variability on a time scale of several hundred years during the last few thousand years. These variations are traced in the strength and profile of the CO rotational lines and in the SED. We have consistently simulated the behaviour of both tracers using radiative transfer codes that allow for non-constant mass-loss rates.

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Theoretical model atmosphere spectra used for the calibration of infrared instruments

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One of the key ingredients in establishing the relation between input signal and output flux from a spectrometer is accurate determination of the *spectrophotometric calibration*. In the case of spectrometers onboard satellites, the accuracy of this part of the calibration pedigree is ultimately linked to the accuracy of the set of reference spectral energy distributions (SEDs) that the spectrophotometric calibration is built on.
In this paper, we deal with the spectrophotometric calibration of *infrared* (IR) spectrometers onboard satellites in the 2 to 200 μm wavelength range. We aim at comparing the different reference SEDs used for the IR spectrophotometric calibration. The emphasis is on the reference SEDs of *stellar standards* with spectral type later than A0, with special focus on the theoretical model atmosphere spectra.
Using the MARCS model atmosphere code, spectral reference SEDs were constructed for a set of IR stellar standards (A dwarfs, solar analogs, G9-M0 giants). A detailed error analysis was performed to estimate proper uncertainties on the predicted flux values.
It is shown that the uncertainty on the predicted fluxes can be as high as 10 %, but in case high-resolution observational optical or near-IR data are available, and IR excess can be excluded, the uncertainty on medium-resolution SEDs can be reduced to 1–2 % in the near-IR, to ∼3 % in the mid-IR, and to ∼5 % in the far-IR. Moreover, it is argued that theoretical stellar atmosphere spectra are at the moment the best representations for the IR fluxes of cool stellar standards.
When aiming at a determination of the spectrophotometric calibration of IR spectrometers better than 3 %, effort should be put into constructing an appropriate set of stellar reference SEDs based on theoretical atmosphere spectra for some 15 standard stars with spectral types between A0 V and M0 III.

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The molecular and dusty composition of Betelgeuse's inner circumstellar environment

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Context: the study of the atmosphere of red supergiant stars in general and of Betelgeuse (α Orionis) in particular is

of prime importance to understand dust formation and how mass is lost to the interstellar medium in evolved massive stars.

Aims: a molecular shell, the MOLsphere (Tsuji, 2000a), in the atmosphere of Betelgeuse has been proposed to account for the near- and mid-infrared spectroscopic observations of Betelgeuse. The goal is to further test this hypothesis and to identify some of the molecules in this MOLsphere.

Methods: we report on measurements taken with the mid-infrared two-telescope beam combiner of the VLTI, MIDI, operated between 7.5 and 13.5 μm. The data are compared to a simple geometric model of a photosphere surrounded by a warm absorbing and emitting shell. Physical characteristics of the shell are derived: size, temperature and optical depth. The chemical constituents are determined with an analysis consistent with available infrared spectra and interferometric data.

Results: the MIDI data are well modeled with a geometrically thin shell whose radius varies from 1.31 to 1.43 $R_\star$ across the N band with a typical temperature of 1550 K. We are able to account for the measured optical depth of the shell in the N band, the ISO-SWS spectrum and K and L band interferometric data with a shell whose inner and outer radii are given by the above range and with the following species and densities: H_2O ($7.1 \pm 4.7 \times 10^{19}$ cm^{-2}), CO ($3.0 \pm 1.5 \times 10^{20}$ cm^{-2}), SiO ($4.0 \pm 1.1 \times 10^{20}$ cm^{-2}), Al_2O_3 ($2.4 \pm 0.5 \times 10^{15}$ cm^{-2}).

Conclusions: these results confirm the MOLsphere model. We bring evidence for more constituents and for the presence of species participating in the formation of dust grains in the atmosphere of the star, i.e. well below the distance at which the dust shell is detected. We believe these results bring key elements to the understanding of mass loss in Betelgeuse and red supergiants in general and bring support to the dust-driven scenario.

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Spitzer Infrared Spectrograph Observations of Magellanic Cloud Planetary Nebulae: the nature of dust in low metallicity circumstellar ejecta

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We present 5–40 μm spectroscopy of 41 planetary nebulae (PNe) in the Magellanic Clouds, observed with the Infrared Spectrograph on board the *Spitzer Space Telescope*. The spectra show the presence of a combination of nebular emission lines and solid-state features from dust, superimposed on the thermal IR continuum.

By analyzing the 25 LMC and 16 SMC PNe in our sample we found that the IR spectra of 14 LMC and 4 SMC PNe are dominated by nebular emission lines, while the other spectra show solid-state features. We observed that the solid-state features are compatible with carbon-rich dust grains (SiC, polycyclic aromatic hydrocarbons (PAHs), etc.) in most cases, except in three PNe showing oxygen-rich dust features. The frequency of carbonaceous dust features is generally higher in LMC than in SMC PNe.

The spectral analysis allowed the correlations of the dust characteristics with the gas composition and morphology, and the properties of the central stars. We found that: 1) all PNe with carbonaceous dust features have C/O>1, none of these being bipolar or otherwise highly asymmetric; 2) all PNe with oxygen-rich dust features have C/O<1, with probable high mass progenitors if derived from single-star evolution (these PNe are either bipolar or highly asymmetric); 3) the dust temperature tracks the nebular and stellar evolution; and 4) the dust production efficiency depends on metallicity, with low metallicity environments not favoring dust production.

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The evolution of planetary nebulae IV. On the physics of the luminosity function

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The luminosity function of planetary nebulae, in use for about two decades in extragalactic distance determinations, is still subject to controversial interpretations.
The physical basis of the luminosity function is investigated by means of several evolutionary sequences of model planetary nebulae computed with a 1D radiation-hydrodynamics code.
The nebular evolution is followed from the vicinity of the asymptotic-giant branch across the Hertzsprung-Russell diagram until the white-dwarf domain is reached, using various central-star models coupled to different initial envelope configurations. Along each sequence the relevant line emissions of the nebulae are computed and analysed.
Maximum line luminosities in Hβ and [O III] 5007 Å are achieved at stellar effective temperatures of about 65 000 K and 95 000...100 000 K, respectively, provided the nebula remains optically thick for ionising photons. In the optically thin case, the maximum line emission occurs at or shortly after the thick/thin transition. Our models suggest that most planetary nebulae with hotter ($\gtrsim$45 000 K) central stars are optically thin in the Lyman continuum, and that their [O III] 5007 Å emission fails to explain the bright end of the observed planetary nebulae luminosity function. However, sequences with central stars of $\gtrsim$0.6 $M_\odot$ and rather dense initial envelopes remain virtually optically thick and are able to populate the bright end of the luminosity function. Individual luminosity functions depend strongly on the central-star mass and on the variation of the nebular optical depth with time.
Hydrodynamical simulations of planetary nebulae are essential for any understanding of the basic physics behind their observed luminosity function. In particular, our models do not support the claim of Marigo et al. (2004) according to which the maximum 5007 Å luminosity occurs during the recombination phase well beyond 100 000 K when the stellar luminosity declines and the nebular models become, at least partially, optically thick. Consequently, there is no need to invoke relatively massive central stars of, say > 0.7 $M_\odot$, to account for the bright end of the luminosity function.

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Suzaku Observations of the North Polar Spur: Evidence for Nitrogen Enhancement

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We present observations of the North Polar Spur (NPS) using the X-ray Imaging Spectrometer (XIS) aboard the Suzaku X-ray satellite. The NPS is a large region of enhanced soft X-ray and radio emission projected above the plane of the Galaxy, likely produced by a series of supernovae and stellar winds from the nearby Sco-Cen OB association. The exceptional sensitivity and spectral resolution of the XIS below 1 keV allow unprecedented probing of low-energy spectral lines, including C VI (0.37 keV) and N VII (0.50 keV), and we have detected highly-ionized nitrogen toward the NPS for the first time. For this single pointing toward the brightest 3/4 keV emission ($l = 26.8°$, $b = +22.0°$), the best-fit NPS emission model implies a hot ($kT \sim 0.3$ keV), collisional ionization equilibrium (CIE) plasma with

depleted C, O, Ne, Mg, and Fe abundances of less than 0.5 solar, but an enhanced N abundance, with $N/O = 4.0^{+0.4}_{-0.5}$ times solar. The temperature and total thermal energy of the gas suggest heating by one or more supernovae, while the enhanced nitrogen abundance is best explained by enrichment from stellar material that has been processed by the CNO cycle. Due to the time required to develop AGB stars, we conclude that this N/O enhancement cannot be caused by the Sco-Cen OB association, but may result from a previous enrichment episode in the solar neighborhood.

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Bayesian posterior classification of planetary nebulae according to the Peimbert types

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Galactic planetary nebulae are observed with a wide variety of kinematic properties, spatial distribution, chemical composition and morphologies, comprising members of the dominant stellar populations of our Galaxy. Due to their broad astrophysical interest, a proper characterization of these populations is of major importance. In this paper we present a re-analysis of the criteria used to characterize the Peimbert classes I, IIa, IIb, III and IV, through a statistical study of a large sample of planetary nebulae previously classified according to these groups. In the original classification, it is usual to find planetary nebulae that cannot be associated with a single type; these most likely have dubious classifications into two or three types. Statistical methods can greatly contribute in providing a better characterization of planetary nebulae groups. We use the Bayes Theorem to calculate the posterior probabilities for an object to be member of each of the types I, IIa, IIb, III and IV. This calculation is particularly important for planetary nebulae that are ambiguously classified in the traditional method. The posterior probabilities are defined from the probability density function of classificatory parameters of a well-defined sample, composed only by planetary nebulae unambiguously fitted into the Peimbert types. Because the probabilities depend on the available observational data, they are conditional probabilities, and, as new observational data are added to the sample, the classification of the nebula can be improved, to take into account this new information. This method differs from the original classificatory scheme, because it provides a quantitative result of the representativity of the object within its group. Also, through the use of marginal distributions it is possible to extend the Peimbert classification even to those objects for which only a few classificatory parameters are known. We found that ambiguities in the classification of planetary nebulae into the Peimbert types, should be associated to difficulties in defining sharp boundaries for the progenitor star mass for each of these types. Those can be at least partially explained by real overlaps of some of the parameters that characterize the different stellar populations. Those results suggest the need of a larger number of classificatory parameters for a reliable physical classification of planetary nebulae.

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Stellar Models and Yields of Asymptotic Giant Branch Stars

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We present stellar yields calculated from detailed models of low and intermediate-mass asymptotic giant branch (AGB) stars. We evolve models with a range of mass from 1 to 6 $M_{\odot}$, and initial metallicities from solar to $1/200^{\rm th}$ of the solar metallicity. Each model was evolved from the zero age main sequence to near the end of the thermally-pulsing

AGB phase, and through all intermediate phases including the core He-flash for stars initially less massive than 2.5 $M_{\odot}$. For each mass and metallicity, we provide tables containing structural details of the stellar models during the TP-AGB phase, and tables of the stellar yields for 74 species from hydrogen through to sulphur, and for a small number of iron-group nuclei. All tables are available for download. Our results have many applications including use in population synthesis studies and the chemical evolution of galaxies and stellar systems, and for comparison to the composition of AGB and post-AGB stars and planetary nebulae.

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Asteroseismology of red giants: photometric observations of Arcturus by SMEI

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We present new results on oscillations of the K1.5 III giant Arcturus (α Boo), from analysis of just over 2.5 yr of precise photometric observations made by the Solar Mass Ejection Imager (SMEI) on board the Coriolis satellite. A strong mode of oscillation is uncovered by the analysis, having frequency 3.51 ± 0.03 micro-Hertz. By fitting its mode peak, we are able offer a highly constrained direct estimate of the damping time (24 ± 1 days). The data also hint at the possible presence of several radial-mode overtones, and maybe some non-radial modes. We are also able to measure the properties of the granulation on the star, with the characteristic timescale for the granulation estimated to be 0.50 ± 0.05 days.

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XMM observation of 1RXS J180431.1–273932: a new M-type X-ray binary with a 494 s-pulse period neutron star?

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Low-mass X-ray binaries are binary systems composed of a compact object and a low-mass star. Recently, a new class of these systems, known as symbiotic *X*-ray binaries (with a neutron star with a M-type giant companion), has been discovered. Here, we present long-duration *XMM* observations of the source 1RXS J180431.1–273932. Temporal and spectral analysis of the source was performed along with a search for an optical counterpart. We used a Lomb-Scargle periodogram analysis for the period search and evaluated the confidence level using Monte-Carlo simulations. The source is characterized by regular pulses so that it is most likely a neutron star. A modulation of 494.1 ± 0.2 s (3σ error) was found with a confidence level of >99%. Evidence of variability is also present, since the data show a rate of change in the signal of $\sim -7.7 \times 10^{-4}$ counts s^{-1} hr^{-1}. A longer observation will be necessary in order to determine if the source shows any periodic behavior. The spectrum can be described by a power law with photon index $\Gamma \sim 1$ and a Gaussian line at 6.6 keV. The X-ray flux in the 0.2–10 keV energy band is 5.4×10^{-12} erg s^{-1} cm^{-2}. The identification of an optical counterpart (possibly an M6 III red-giant star with an apparent visual magnitude of $\simeq 17.6$) allows a conservative distance of ~ 10 kpc to be estimated. Other possibilities are also discussed. Once the distance was estimated, we got an *X*-ray luminosity of $L_X \lesssim 6 \times 10^{34}$ erg s^{-1}, which is consistent with the typical *X*-ray luminosity of a symbiotic LMXB system.

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A spectral atlas of post-main-sequence stars in ω Centauri: kinematics, evolution, enrichment and interstellar medium

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We present a spectral atlas of the post-main-sequence population of the most massive Galactic globular cluster, ω Centauri. Spectra were obtained of more than 1500 stars selected as uniformly as possible from across the (B, B–V) colour-magnitude diagram of the proper motion cluster member candidates of van Leeuwen et al. (2000). The spectra were obtained with the 2dF multi-fibre spectrograph at the Anglo Australian Telescope, and cover the approximate range $\lambda \sim 3840$–4940 Å at a resolving power of $\lambda/\Delta\lambda \simeq 2000$. This constitutes the most comprehensible spectroscopic survey of a globular cluster. We measure the radial velocities, effective temperatures, metallicities and surface gravities by fitting ATLAS9 stellar atmosphere models. We analyse the cluster membership and stellar kinematics, interstellar absorption in the Ca II K line at 3933 Å, the RR Lyrae instability strip and the extreme horizontal branch, the metallicity spread and bimodal CN abundance distribution of red giants, nitrogen and s-process enrichment, carbon stars, pulsation-induced Balmer line emission on the asymptotic giant branch (AGB), and the nature of the post-AGB and UV-bright stars. Membership is confirmed for the vast majority of stars, and the radial velocities clearly show the rotation of the cluster core. We identify long-period RR Lyrae-type variables with low gravity, and low-amplitude variables coinciding with warm RR Lyrae stars. A barium enhancement in the coolest red giants indicates that 3$^{\rm rd}$ dredge-up operates in AGB stars in ω Cen. This is distinguished from the pre-enrichment by more massive AGB stars, which is also seen in our data. The properties of the AGB, post-AGB and UV-bright stars suggest that RGB mass loss may be less efficient at very low metallicity, [Fe/H]$\ll -1$, increasing the importance of mass loss on the AGB. The catalogue and spectra are made available via CDS.

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Near-Infrared photometry of carbon stars in the Sagittarius dwarf irregular galaxy and DDO 210

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We investigate the intermediate-age asymptotic giant branch stellar population of two Local Group dwarf irregular galaxies to characterize their carbon star population in near-infrared (IR). Our work is based on J and K-band SOFI near-IR photometry complemented with optical ground based and HST photometry. We show that near-IR photometry is a very powerful tool for carbon star detection. We recovered two out of three previously-known carbon stars in DDO 210 and discovered six additional objects in this galaxy which have optical and near-IR colors consistent with carbon giants. This brings the total number of bona-fide C-star candidates in DDO 210 to nine. We detected a large population of C-star candidates in SagDIG, 18 of which were previously identified in Demers & Battinelli (2002) and Cook (1987), and six new bona-fide carbon stars. We present their optical and near-IR colors and use their luminosity function to put constraints on the star formation history in this dwarf irregular galaxy.

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The interaction of planetary nebulae and their AGB progenitors with the interstellar medium

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Interaction with the Interstellar Medium (ISM) cannot be ignored in understanding planetary nebula (PN) evolution and shaping. In an effort to understand the range of shapes observed in the outer envelopes of PNe, we have run a comprehensive set of three-dimensional hydrodynamic simulations, from the beginning of the asymptotic giant branch (AGB) superwind phase until the end of the post–AGB/PN phase. A 'triple-wind' model is used, including a slow AGB wind, fast post–AGB wind and third wind reflecting the linear movement through the ISM. A wide range of stellar velocities, mass-loss rates and ISM densities have been considered. We find ISM interaction strongly affects outer PN structures, with the dominant shaping occuring during the AGB phase. The simulations predict four stages of PN–ISM interaction whereby the PN is initially unaffected (1), then limb-brightened in the direction of motion (2), then distorted with the star moving away from the geometric centre (3) and finally so distorted that the object is no longer recognisable as a PN and may not be classed as such (4). Parsec-size shells around PN are predicted to be common. The structure and brightness of ancient PNe is largely determined by the ISM interaction, caused by rebrightening during the second stage; this effect may address the current discrepancies in Galactic PN abundance. The majority of PNe will have tail structures. Evidence for strong interaction is found for all known planetary nebulae in globular clusters.

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The Luminous and Carbon-Rich Supernova 2006gz: A Double Degenerate Merger?

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Spectra and light curves of SN 2006gz show the strongest signature of unburned carbon and one of the slowest fading light curves ever seen in a type Ia event ($\Delta m_1 5 = 0.69 \pm 0.04$). The early-time Si II velocity is low, implying it was slowed by an envelope of unburned material. Our best estimate of the luminosity implies $M_V = -19.74$ and the production of ~ 1.2 $M_\odot$ of ^{56}Ni. This suggests a super-Chandrasekhar mass progenitor. A double degenerate merger is consistent with these observations.

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The Formation of Crystalline Dust in AGB Winds from Binary Induced Spiral Shocks

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As stars evolve along the Asymptotic Giant Branch, strong winds are driven from the outer envelope. These winds

form a shell, which may ultimately become a planetary nebula. Many planetary nebulae are highly asymmetric, hinting at the presence of a binary companion. Some post-Asymptotic Giant Branch objects are surrounded by torii of crystalline dust, but there is no generally accepted mechanism for annealing the amorphous grains in the wind to crystals. In this Letter, we show that the shaping of the wind by a binary companion is likely to lead to the formation of crystalline dust in the orbital plane of the binary.

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HST Observations of Chromospheres in Metal Deficient Field Giants

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HST high resolution spectra of metal-deficient field giants more than double the stars in previous studies, span about 3 magnitudes on the red giant branch, and sample an abundance range [Fe/H]= −1 to −3. These stars, in spite of their age and low metallicity, possess chromospheric fluxes of Mg II (2800 Å) that are within a factor of 4 of Population I stars, and give signs of a dependence on the metal abundance at the lowest metallicities. The Mg II k-line widths depend on luminosity and correlate with metallicity. Line profile asymmetries reveal outflows that occur at lower luminosities ($M_V = -0.8$) than detected in Ca K and Hα lines in metal-poor giants, suggesting mass outflow occurs over a larger span of the red giant branch than previously thought, and confirming that the Mg II lines are good wind diagnostics. These results do not support a magnetically dominated chromosphere, but appear more consistent with some sort of hydrodynamic, or acoustic heating of the outer atmospheres.

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VLT / Infrared Integral Field Spectrometer Observations of Molecular Hydrogen Lines in the Knots in the Planetary Nebula NGC 7293 (the Helix Nebula)

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Knots are commonly found in nearby planetary nebulae (PNe) and star forming regions. Within PNe, knots are often found to be associated with the brightest parts of the nebulae and understanding the physics involved in knots may reveal the processes dominating in PNe. As one of the closest PNe, the Helix Nebula (NGC 7293) is an ideal target to study such small-scale (∼ 300 AU) structures. We have obtained infrared integral spectroscopy of a comet-shaped knot in the Helix Nebula using SINFONI on the Very Large Telescope at high spatial resolution (50-125 mas). With

spatially resolved 2 μm spectra, we find that the H_2 rotational temperature within the cometary knots is uniform. The rotational-vibrational temperature of the cometary knot (situated in the innermost region of the nebula, 2.5′ away from the central star), is 1800 K, higher than the temperature seen in the outer regions (5-6′ from the central star) of the nebula (900 K), showing that the excitation temperature varies across the nebula. The obtained intensities are reasonably well fitted with 27 km s^{-1} C-type shock model. This ambient gas velocity is slightly higher than the observed [He II] wind velocity of 13 km s^{-1}. The gas excitation can also be reproduced with a PDR (photo dominant region) model, but this requires an order of magnitude higher UV radiation. Both models have limitations, highlighting the need for models that treats both hydrodynamical physics and the PDR.

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Spitzer Space Telescope spectral observations of AGB stars in the Fornax dwarf spheroidal galaxy

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We have observed five carbon-rich AGB stars in the Fornax dwarf spheroidal (dSph) galaxy, using the Infrared Spectrometer on board the Spitzer Space Telescope. The stars were selected from a near-infrared survey of Fornax and include the three reddest stars, with presumably the highest mass-loss rates, in that galaxy. Such carbon stars probably belong to the intermediate-age population (2-8 Gyr old and metallicity of [Fe/H]~ -1) of Fornax. The primary aim of this paper is to investigate mass-loss rate, as a function of luminosity and metallicity, by comparing AGB stars in several galaxies with different metallicities. The spectra of three stars are fitted with a radiative transfer model. We find that mass-loss rates of these three stars are $4-7\times10^{-6}$ $M_\odot$ yr^{-1}. The other two stars have mass-loss rates below 1.3×10^{-6} $M_\odot$ yr^{-1}. We find no evidence that these rates depend on metallicity, although we do suggest that the gas-to-dust ratio could be higher than at solar metallicity, in the range 240 to 800. The C_2H_2 bands are stronger at lower metallicity because of the higher C/O ratio. In contrast, the SiC fraction is reduced at low metallicity, due to low silicon abundance. The total mass-loss rate from all known carbon-rich AGB stars into the interstellar medium of this galaxy is of the order of 2×10^{-5} $M_\odot$ yr^{-1}. This is much lower than that of the dwarf irregular galaxy WLM, which has a similar visual luminosity and metallicity. The difference is attributed to the younger stellar population of WLM. The suppressed gas-return rate to the ISM accentuates the difference between the relatively gas-rich dwarf irregular and the gas-poor dwarf spheroidal galaxies. Our study will be useful to constrain gas and dust recycling processes in low metallicity galaxies.

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Dust-grain processing in circumbinary discs around evolved binaries. The RV Tauri spectral twins RU Cen and AC Her

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Context: We study the structure and evolution of the circumstellar discs around evolved binaries and their impact on the evolution of the central system.
Aims: By combining a wide range of observational data and techniques, we aim to study in detail the binary nature of RU Cen and AC Her, as well as the structure and mineralogy of the circumstellar environment.
Methods: We combine a multi-wavelength observational program with a detailed 2D radiative transfer study. Our radial velocity program is instrumental in the study of the nature of the central stars, while our Spitzer spectra complimented with the broad-band spectral energy distribution (SED) are used to constrain mineralogy, grain sizes and physical structure of the circumstellar environment.
Results: We determine the orbital elements of RU Cen showing that the orbit is highly eccentric with a large velocity amplitude despite the rather long period of 1500 days. The infrared spectra of both objects are very similar and the spectral dust features are dominated by magnesium-rich crystalline silicates. The small peak-to-continuum ratios are interpreted as being due to large grains. Our model contains two components with a cold midplain dominated by large grains, and the near- and mid-IR which is dominated by the emission of smaller silicates. The infrared excess is well modelled assuming a hydrostatic passive irradiated disc. The profile-fitting of the dust resonances shows that the grains must be very irregular.
Conclusions: These two prototypical RV Tauri pulsators with circumstellar dust are binaries where the dust is trapped in a stable disc. The mineralogy and grain sizes show that the dust is highly processed, both in crystallinity and grain size. The cool crystals show that either radial mixing is very efficient and/or that the thermal history at grain formation has been very different from that in outflows. The physical processes governing the structure of these discs are very similar to those observed in protoplanetary discs around young stellar objects.

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Neon and Sulfur Abundances of Planetary Nebulae in the Magellanic Clouds

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The chemical abundances of neon and sulfur for 25 planetary nebulae (PNe) in the Magellanic Clouds are presented. These abundances have been derived using mainly infrared data from the *Spitzer Space Telescope*. The implications for the chemical evolution of these elements are discussed. A comparison with similarly obtained abundances of Galactic PNe and H II regions and Magellanic Clouds H II regions is also given. The average neon abundances are 6.0×10^{-5} and 2.7×10^{-5} for the PNe in the Large and Small Magellanic Clouds respectively. These are $\sim$1/3 and 1/6 of the average abundances of Galactic planetary nebulae to which we compare. The average sulfur abundances for the LMC and SMC are respectively 2.7×10^{-6} and 1.0×10^{-6}. The Ne/S ratio (23.5) is on average higher than the ratio found in Galactic PNe (16) but the range of values in both data sets is similar for most of the objects. The neon abundances found in PNe and H II regions agree with each other. It is possible that a few (3-4) of the PNe in the sample have experienced some neon enrichment, but for two of these objects the high Ne/S ratio can be explained by their very low sulfur abundances. The neon and sulfur abundances derived in this paper are also compared to previously published abundances using optical data and photo-ionization models.

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Constraining white-dwarf kicks in globular clusters : II. Observational Significance

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If the winds of an asymptotic-giant-branch stars are sufficiently strong and slightly asymmetric, they can alter the star's trajectory through a globular cluster; therefore, if these winds are asymmetric, one would expect young white dwarfs to be less radially concentrated than either their progenitors or older white dwarfs in globular clusters. This latter effect has recently been observed. Additionally the young white dwarfs should have larger typical velocities than their progenitors. After phase mixing this latter effect is vastly diminished relative to the changes in the spatial distribution of young white dwarfs with kicks, so it is more difficult to detect than the change in the spatial distribution. The most powerful kinematic signature is the change in the eccentricity of the orbits that is revealed through the distribution of the position angles of proper motion.

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The Unusual Variability of the Large Magellanic Cloud Planetary Nebula RPJ 053059−683542

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We present images and light curves of the bipolar Planetary Nebula RPJ 053059−683542 that was discovered in the Reid-Parker AAO/UKST Hα survey of the Large Magellanic Cloud (LMC). The emission from this object appears entirely nebular, with the central star apparently obscured by a central band of absorption that bisects the nebula. The light curves, which were derived from images from the SuperMACHO project at CTIO, showed significant, spatially resolved variability over the period 2002 January through 2005 December. Remarkably, the emission from the two bright lobes of the nebula vary either independently, or similarly but with a phase lag of at least one year. The optical spectra show a low level of nebular excitation, and only modest N enrichment. Infrared photometry from the 2MASS and SAGE surveys indicates the presence of a significant quantity of dust. The available data imply that the central star has a close binary companion, and that the system has undergone some kind of outburst event that caused the nebular emission to first brighten and then fade. Further monitoring, high-resolution imaging, and detailed IR polarimetry and spectroscopy would uncover the nature of this nebula and the unseen ionizing source.

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Cool carbon stars in the halo: new very red or distant objects

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The goal of this paper is to present and analyse a new sample of cool carbon (C) stars located in the Galactic halo.

These rare objects are discovered by searching the 2MASS point-source catalogue for candidates having near-infrared colours typical of C stars. Optical spectroscopy is subsequently performed. Twenty-three new C stars were discovered, with their K_s magnitude in the range 6 to 13.3. Spectra are typical of N-type carbon stars with C_2 and CN bands and sometimes Hα in emission. One object is a S-type star. When the objects are bright enough ($V \leq 15.5$), the data of the Northern Sky Variability Survey can be exploited. In all cases, stars belonging to this survey show light variations confirming that they are AGB stars. Distances and galactocentric XYZ coordinates have been estimated by assuming these stars to be similar in luminosity to those of the Sagittarius dwarf galaxy. Four objects are particularly red with J-$K_s > 3$, with two located at more than 5 kpc from the Galactic plane. Eight additional objects with similar properties are found in the literature and our previous works. These 12 C stars could be useful to study mass loss at low metallicity. Two other objects are remarkably far from the Sun, at distances of 95 and 110 kpc. They are located, together with two other C stars previously found, in the region $Z < -60$ kpc in which the model of Law et al. (2005) predicts the Sgr Stream to have a loop.

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The chemical composition of planetary nebulae and H II regions in NGC 3109

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We present deep spectrophotometry for a sample of 8 planetary nebulae (PNe) and 12 H II regions distributed throughout the dwarf irregular galaxy NGC 3109, in order to analyze the chemical composition of both types of nebulae. We describe the observations and data reduction and present line intensities for the nebular emission lines detected. The physical conditions and the abundances of He, O, Ne, N, S and Ar are derived, using the classical T_e-based method. We confirm our previous identification of PNe and H II regions based on photometry, except for one object that we argue is a compact H II region rather than a PN. We find that the chemical composition of the ISM in NGC 3109, as sampled by its H II regions, is remarkably uniform. The oxygen abundance is $\log \mathrm{O/H} + 12 = 7.77 \pm 0.07$ in this galaxy, as compared to 8.05 ± 0.09 for the SMC (for which we rederived the metallicity in a homogeneous way. PNe show significantly higher oxygen abundances in NGC 3109: $\log \mathrm{O/H} + 12 = 8.16 \pm 0.19$. We argue that, similarly to what has been suggested for some of the PNe in the Magellanic Clouds and other metal-poor galaxies, oxygen in the PNe in NGC 3109 is affected by dredge up in their progenitors. This could be also the case for neon although the uncertainties for this element are bigger. From our analysis, we conclude that these two elements are not always a safe indicator of the chemical composition of the ISM at low metallicities. An alternative to the O and Ne enrichment in PNe is that the low metallicity in H II regions has been caused by dilution of the ISM due interaction with a neighbor galaxy about a Gyr ago.
The excitation patterns of the PNe in NGC 3109 are very different from the excitation patterns of PNe in other galaxies. This issue needs to be investigated further, as it implies that the evolution of PNe depend upon the properties of their progenitor stellar populations, which vary from galaxy to galaxy. This should affect the PN luminosity function and its use as a distance indicator.
Regarding individual objects, we find that the PN named PN 14 shows clear WR features, very low excitation and high density. Thus it is similar to some of the galactic PNe ionized by late [WC] stars.

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Spitzer's View of Planetary Nebulae

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The Spitzer Space Telescope, NASA's Great Observatory for infrared astronomy, has made available new tools for the investigation of the infrared properties of planetary nebulae. The three instruments onboard, including the Infrared Array Camera (IRAC), the Multiband Imaging Photometer for Spitzer (MIPS), and the Infrared Spectrograph (IRS), provide imaging capability from 3.6 to 160 μm, and low and moderate resolution spectroscopy from 5.2 to 38 μm. In this paper I review recent Spitzer results concerning planetary nebulae and their asymmetrical structures.

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Resolving the Multiple Outflows in the Egg Nebula with Keck II Laser Guide Star Adaptive Optics

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The Egg Nebula has been regarded as the archetype of bipolar proto-planetary nebulae, yet we lack a coherent model that can explain the morphology and kinematics of the nebular and dusty components observed at high-spatial and spectral resolution. Here, we report on two sets of observations obtained with the Keck Adaptive Optics Laser Guide Star: H to M-band NIRC2 imaging, and narrow bandpath K-band OSIRIS 3-D imaging-spectroscopy (through the H_2 2.121 μm emission line). While the central star or engine remains un-detected at all bands, we clearly resolve the dusty components in the central region and confirm that peak A is not a companion star. The spatially-resolved spectral analysis provide kinematic information of the H_2 emission regions in the eastern and central parts of the nebula and show projected velocities for the H_2 emission higher than 100 km s^{-1}. We discuss these observations against a possible formation scenario for the nebular components.

Poster contribution, published in "Asymetrical Planetary Nebula IV", eds. Romano L.M. Corradi, Arturo Manchado & Noam Soker
Available from arXiv:0709.0473

Thermohaline mixing in low-mass giants: RGB and beyond

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Thermohaline mixing has recently been proposed to occur in low mass red giants, with large consequence for the chemical yields of low mass stars. We investigate the role of thermohaline mixing during the evolution of stars

between 1 $M_\odot$ and 3 $M_\odot$. We use a stellar evolution code which includes rotational mixing and internal magnetic fields. We confirm that thermohaline mixing has the potential to destroy most of the ^{3}He which is produced earlier on the main sequence during the red giant stage, in stars below 1.5 $M_\odot$. We find this process to continue during core helium burning and beyond. We find rotational and magnetic mixing to be negligible compared to the thermohaline mixing in the relevant layers, even if the interaction of thermohaline motions with the differential rotation may be essential to establish the time scale of thermohaline mixing in red giants.

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Yields from single AGB stars

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In order to understand the composition of planetary nebulae we first need to study the nucleosynthesis occurring in the progenitor star during the thermally-pulsing Asymptotic Giant Branch (AGB) phase. I present an overview of single AGB evolution, with an emphasis on the mixing processes that alter the envelope composition, followed by a discussion of the stellar yields available from single AGB stellar models.

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Planetary Nebulae Principles & Paradigms: Binaries, Accretion, Magnetic Fields

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Observations suggest that many, if not all, post AGB systems evolve through an aspherical outflow phase. Such outflows require a sufficient engine rotational energy which binaries can provide. Via common envelope evolution, binaries can directly eject equatorial outflows or produce poloidal outflows from magnetized accretion disks around the primary or secondary. We discuss how accretion driven magnetohydrodynamic outflow models all make similar predictions for the outflow power and speed and we distinguish between the launch vs. propagation regimes of such outflows. We suggest that the high velocity bipolar outflows observed in planetary nebulae (PNe) and the lower velocity but higher power bipolar outflows observed in pre-PNe (pPNe) are kinematically consistent with time dependent accretion onto a white dwarf (WD) within a depleting envelope. Since the WD primary core is always present in all post-AGB systems, accretion onto this core is potentially common. Previous work has focused on core accretion from sub-stellar companions, but low mass stellar companions may be more important, and further work is needed.

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3D Photoionisation Modelling of NGC 6302

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We present a three-dimensional photoionisation and dust radiative transfer model of NGC 6302, an extreme, high-excitation planetary nebula. We use the 3D photoionisation code MOCASSIN to model the emission from the gas and dust. We have produced a good fit to the optical emission-line spectrum, from which we derived a density distribution for the nebula. A fit to the infrared coronal lines places strong constraints on the properties of the unseen ionising source. We find the best fit comes from using a 220,000 K hydrogen-deficient central star model atmosphere, indicating that the central star of this PN may have undergone a late thermal pulse.
We have also fitted the overall shape of the ISO spectrum of NGC 6302 using a dust model with a shallow power-law size distribution and grains up to 1.0μm in size. To obtain a good fit to the infrared SED the dust must be sufficiently recessed within the circumstellar disk to prevent large amounts of hot dust at short wavelengths, a region where the ISO spectrum is particularly lacking. These and other discoveries are helping to unveil many properties of this extreme object and trace it's evolutionary history.

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Available from arXiv:0709.2122

Shaping Planetary Nebulae by Jets

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We conduct 2D axisymmetrical hydrodynamical simulations to investigate the interaction of a collimated fast wind (CFW; wide jets) with a spherical AGB wind. The code includes radiative cooling. We find that the shape of the planetary nebula (PN) is sensitive to the exact mass loss history of the AGB wind, and the opening angle of the CFW. Some typical PN morphologies are obtained, but many other observed morphologies seem to require more ingredients than what we assume in our present simulations, e.g., equatorial AGB wind, and ionization and fast wind during the PN phase. The hot bipolar bubble formed by the jets is an X-ray source.

Poster contribution, published in APN4

Techniques for simulating radiative transfer through porous media

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In this contribution, I discuss some basic techniques that can be used to simulate radiative transfer through porous media. As specific examples, I consider scattering transfer through a clumped slab, and X-ray emission line formation in a clumped wind.

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Planetary nebulae, tracers of stellar nucleosynthesis

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We review the information that planetary nebulae and their immediate progenitors, the post-AGB objects, can provide to probe the nucleosynthesis and mixing in low and intermediate mass stars. We emphasize new approaches based on high signal-to-noise spectroscopy of planetary nebulae and of their central stars. We mention some of the problems still to overcome. We emphasize that, as found by several authors, planetary nebulae in low metallicity environments cannot be used to probe the oxygen abundance in the interstellar medium out of which their progenitors were formed, because of abundance modification during stellar evolution.

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Horizontal Branch Stars and the Ultraviolet Universe

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Extremely hot horizontal branch (HB) stars and their progeny are widely considered to be responsible for the "ultraviolet upturn" (or UVX) phenomenon observed in elliptical galaxies and the bulges of spirals. Yet, the precise evolutionary channels that lead to the production of these stars remain the source of much debate. In this review, we discuss two key physical ingredients that are required in order for reliable quantitative models of the UV output of stellar populations to be computed, namely, the mass loss rates of red giant branch stars and the helium enrichment "law" at high metallicities. In particular, the recent evidence pointing towards a strong enhancement in the abundances of the alpha-elements in the Galactic bulge (compared to the disk), and also the available indications of a similar overabundance in (massive) elliptical galaxies, strongly suggest that the helium abundance Y may be higher in ellipticals and bulges than it is in spiral disks by an amount that may reach up to 0.15 at [Fe/H] $\sim +0.5$. If so, this would strongly favor the production of hot HB stars at high metallicity in galactic spheroids. We also discuss the existence of mass loss recipes beyond the commonly adopted Reimers "law" that are not only more consistent with the available empirical data, but also much more favorable to the production of extended HB stars at high metallicity. Finally, we discuss new empirical evidence that suggests that different evolutionary channels may be responsible for the production of EHB stars in the field and in clusters.

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Founded in 1911, The University of Hong Kong is committed to the highest international standards of excellence in teaching and research. The University has a comprehensive range of study programmes and research disciplines, with 20,000 undergraduate and postgraduate students from 50 countries, and a complement of 1,200 academic members of staff.

As the University approaches its 100^{th} anniversary, a major human resource expansion plan has been launched to provide 200 new academic positions. The purpose of this Centenary Recruitment Plan is to enhance our research competitiveness and to facilitate the introduction and delivery of a new four-year undergraduate curriculum from 2012.

Building on Hong Kong's international status and its mission to serve China, the University offers an intellectually-stimulating and culturally-rich academic environment, with attractive remuneration packages.

Applications are invited for appointment as Associate Professor/Assistant Professor in Observational Infrared/Submillimetre Astronomy in the Department of Physics, from January 1, 2008 or as soon as possible thereafter. The post will initially be made on a three-year term. Appointment with tenure will be considered during the second three-year contract.

The Department of Physics has strong groups in condensed matter physics, including nanoscience and nanotechnology, as well as in theoretical and observational astronomy. We seek an astronomer with observational experience with ground-based or space-based infrared/submillimetre telescopes who can initiate programmes in future facilities such as SOFIA, Herschel, ALMA, etc.

The appointee should have a demonstrated record in research and a commitment to excellence in undergraduate and graduate teaching. Research start-up funds will be available. Information about the Department can be obtained at http://www.physics.hku.hk/.

Annual salaries will be in the following ranges (subject to review from time to time at the entire discretion of the University):

Associate Professor : HK$593,100 – 917,220$
$Assistant Professor : HK$451,980 – 698,520$
(approximately US$1 = HK$7.8)

The appointment will attract a contract-end gratuity and University contribution to a retirement benefits scheme, totalling up to 15% of basic salary, as well as leave, and medical/dental benefits. Housing benefits will be provided as applicable. At current rates, salaries tax does not exceed 16% of gross income.

For enquiries of the existing research activities and the specific job requirements, please write to Professor Sun Kwok, Dean of Science (e-mail: sunkwok@hku.hk). Further particulars and application forms (272/302 amended) can be obtained at https://www.hku.hk/apptunit/. Please submit a curriculum vitae including a complete publication list, a research plan, and a statement on teaching, directly to the Appointments Unit (Senior), Human Resource Section, Registry, The University of Hong Kong, Hong Kong (fax: (852) 2540 6735 or 2559 2058; e-mail: senrappt@hkucc.hku.hk) quoting the reference number RF-2006/2007-590.

The University is an equal opportunity employer

See also https://www.hku.hk/apptunit/

University of Hong Kong
Postdoctoral Fellow

Applications are invited for a position as postdoctoral fellow in the Department of Physics, University of Hong Kong. The evolved stars group has active research programs on planetary nebulae, AGB stars, and interstellar chemistry, with observation programs in a variety of ground-based and space telescopes.

We are looking for a candidate with a background in the area of advanced stages of stellar evolution, interstellar medium, or solar system, preferably with observational experience in optical, infrared, mm/submm, or radio astronomy. The appointment will be for a period of 3 years. Please send curriculum vitae including a publication list, research plan, and the names of three references to Prof. Sun Kwok at sunkwok@hku.hk. The position is available immediately and will remain open until a suitable candidate is found.