NASSP OT1 Student Projects
– 2009 –

Writing a SALT Observing Proposal

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Summary
These projects are expected to take ~5 weeks to complete, starting from 1 April, with completion by 11 May. Three components of the project will be marked, which in totality will comprise 40% of the mark for the OT1 (optical/IR) course, comprising:

1. <u>Written component (50% of project)</u>, consisting of:
    a. *Literature study*. A general description of the observational topic in context with our current understandings and the specific SALT observing proposal. Reference to published papers on the topic.
    b. *Scientific Justification*. This should be a maximum of 2 A4 pages, including figures, diagrams, tables, etc. It should consist of:
        i. a brief summary of the science being attempted (i.e. summarizing 1 a.) and its importance
        ii. a description of the instrument configuration(s) to be used
        iii. a brief discussion on the technical feasibility (e.g. in terms of instrument capability, requested exposure time, total amount of observing time being requested, signal-to-noise needs, etc.).
    c. Summary of the proposed observations. A description and reasoning for the instrument mode choice and details of the instrument configuration(s) (e.g. filter or grating choice) This may have reference to results using the SALT instrument simulation tools (e.g. for S/N or exposure time calculations), with extracts of results from these tools.
    d. A list of the objects to be observed.. The list of target names, their positions and any other relevant information, plus their visibilities (e.g. as obtained from the SALT visibility tool) and finding charts for all of the targets.

2. <u>Submitted SALT Proposal (25%)</u>

On completing the SALT PIPT proposal form, this will be submitted to a pseudo-database, over the internet (by clicking the "submission" button). If successful (email will confirm this), an XML proposal file will be created automatically. You have the option of checking and changing this and resubmitting it before the 11 May deadline.

The final version of the submitted XML file will be assessed in terms of:

- how well it matches the proposal requirements
- how logical and efficient is the observing plan
- how complete is the observing plan (i.e. is there anything missing?)
- any errors in the proposal (e.g. objects not observable)

3. <u>Project Presentation (25%)</u>

Sometime in the week beginning of 11 May (exact date and venue to be confirmed), all students are to make a short presentation to the class on their observing proposals. This will be the in the form of a PowerPoint (or similar) presentation last 15 minutes, with 5 mins for questions.

PROJECTS

#1: Probing High-Redshift Galaxies with Quasar Light

Dr Petri Väisänen, SAAO
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Damped Lyman alpha (DLA) systems are amongst the most powerful un-biased methods of probing high-redshift galaxies. DLAs are quasar absorption systems thought to be the result of a QSO sightline passing through a galaxy: hence once sees absorption lines corresponding to the galaxy's redshift superimposed on the continuum of the background QSO, especially due to the galaxy's neutral hydrogen. The nature of the highest redshift DLAs is still a matter of debate - what kind of galaxies are the hosts of DLAs? Are they low metallicity dwarfs or perhaps already rotating disks?

We propose to study a sample of SDSS QSOs at redshifts of z>2.5. We will be looking for the redshifted Ly-alpha (1215 Ansgtrom) absorption line of galaxies along the line of sight to these QSOs - the further into near-ultraviolet spectral range we are able to observe, the more chances we have of detecting DLAs (the DLAs will lie in-between the redshift of the QSO and the redshifts determined by the bluest observable spectral range). The shape and characteristics of the observed Ly-alpha absorption lines give the neutral hydrogen column densities and we can estimate what kind of objects they are.

At poorer than 5 Angstrom spectral resolution the Ly-alpha absorption line may be confused with blended Ly-alpha forest lines, and thus should be considered as the minimum spectral resolution for the observations. As already said, we need the best possible throughput down close to the atmospheric cut-off in the blue. We require a S/N of approximately 15-20 per pixel in the 4000A region of our spectra.

The total target list is (select two of these):

QSO Name	**redshift (z)**
TXS2034+046	2.95
TXS2131-045	4.35
TXS2320-312	2.55
TXS2338+042	2.59
TXS0017-307	2.68
TXS0214-011	2.46
TXS0246-231	2.90
TXS0304-316	2.54
TXS1025-264	2.67
TXS1445-161	2.41

Tasks:

1. Choose the appropriate instrument
2. Choose the appropriate spectroscopic settings for the instrument taking care to satisfy the scientific needs described above
3. Select 2 galaxies of the target options most suitable for, either (choose one of a, b or c):
    a. observations in the period Feb-April 2009, or
    b. observations in the period July-Sep 2009, or
    c. observations in the period Oct-Dec 2009.
4. Estimate needed exposure times with your settings for your targets.
5. Use PIPT to fill out the observations specifications as you have determined them and submit the proposal.

Potentially useful background reference(s):

Wolfe, A.M., Gawiser, E., Prochaska, J.A., 2005, Annual Reviews of Astronomy & Astrophysics (ARAA), 43, 861
Ellison, S., et al. 2008, Monthly Notices of the Royal Astronomical Society (MNRAS), 388, 1349

#2: Dust in early type galaxies

Dr Petri Väisänen, SAAO
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We propose to observe early-type galaxies with dark dust lanes with SALT. Observations of five galaxies will be performed in six filters that span the whole available spectral range from the near-ultraviolet atmospheric cutoff to the near-infrared.

An extinction law by the dust in the dark lanes will be derived by fitting smooth surface brightness models to the unextinguished stellar part of the galaxies, and subtracting this from the images. This will reveal the relative extinction at each resolution element at each band separately. Absolute photometry or photomeric calibration of the images is not necessary.

We will compare the total-to-selective extinction derived for these galaxies with extinction values of Milky Way dust to derive conclusions about the properties of extragalactic dust, and model dust grain properties outside of our own Galaxy. These observations will also serve as the basis of a later spectroscopy proposal to study the physical characteristics of the dust lanes.

It is important to get high-signal to noise images over the whole galaxy in each filter while simultaneously not saturating the cores of the galaxies. Galaxies are bright, but we are interested also in their very faint outer regions. Flat-fielding will be performed using data images themselves.

Tasks:

1. Choose the appropriate instrument
2. Choose the appropriate filters and other settings
3. Select 2 galaxies of the target options most suitable for (choose one of these options):
    a. observations in the period March-May 2009, or
    b. observations in the period Sep-Nov 2009 or,
    c. observations in the period Dec 2009-Feb 2010.
4. Use PIPT to fill out the observations specifications as you have determined them and submit the proposal.

Target options - selected two galaxies from this list

NGC 1947
NGC 2907
NGC 3302
NGC 4753
NGC 5266
NGC 5745
IC 1575
AM 0052-321
AM 0219-343
AM 1307-464
AM 1444-302
ESO197-10
ESO355-6

Hint:

See the Extragalactic Database NED at http://nedwww.ipac.caltech.edu/ to find the coordinates and approximate brightnesses of the targets.

Potentially useful background Reference(s):

Patil, M.K, et al., 2007, Astronomy & Astrophysics (A&A), 461, 103
Savage B.D. & Mathis J.S., 1979. Annual Reviews of Astronomy & Astrophysics (ARAA), 17, 73.

#3: Secondary Eclipse Radial Velocity Curve of the Polar V895 Cen

Dr David Buckley, SAAO
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The eclipsing polar V895 Cen shows evidence of its secondary star both in photometry and spectroscopy, the latter by the presence of absorption lines of sodium and titanium oxide, seen in the red part of the spectrum.

The aim is to determine the orbital radial velocity curve of the secondary by looking for changes in the line positions over the orbital cycle, in particular the sodium doublet at 818.5 and 819.7 nm.

Tasks:
1. Review our current understanding of this system and identify the spectral lines and their wavelengths that can be used for these observations
2. Choose the appropriate instrument and configurations for the observations
3. Choose a range of potential observing windows with SALT which when combined will cover the entire orbit
4. Write an observing proposal with the PIPT and submit

Hints:
1. The long orbital period (4.75 hours) will mean that a number of SALT tracks will be needed
2. Check the SALT visibility and calculate the phase coverage for the tracks based on the eclipse ephemeris
3. Use the instrument simulators to estimate the exposure time assuming a S/N of ~10 is required per exposure

Reference:
Stobie et al. (1996), *Monthly Notices of the Royal Astronomical Society*, **283**, L127.

#4: Eclipse Observations of Hot-Spots in Polars

Dr Stephen Potter, SAAO
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Polars (also known as AM Herculis systems) are binary stars consisting of a highly magnetic (20-200 MG) white dwarf accreting from a red dwarf companion star. The spin period is synchronized to the orbital period of the system, which falls in the range ~80 to ~500 minutes. Most of a polar’s luminosity arises from the hot *accretion spots*, situated near the magnetic poles of the white dwarf.

The aim of this program is to resolves the eclipses of the polar hotspots in order to determine their sizes with respect to the white dwarf and, if possible, the relative luminosity contributions from the spots (for two pole accretors).

Eclipses of two different objects are required, in two different filters in order to discriminate temperature.

The observations are planned to be done in March 2009.

Tasks:
1. From the list below, select *one* systems to observe, choosing any one of the following criteria:
    a. The longest period system
    b. The shortest period system
    c. A known two-pole accreting system
    d. A relatively unstudied system
    e. A system with a well-observed X-ray eclipse
    f. A system with known Quasi-Periodic Oscillations (QPOs)
2. Review what is already known about the chosen object
3. Select the most appropriate instrument and configuration to undertake these observations
4. Write an observing proposal and submit it

Hint:
1. Check the visibility of eclipses for SALT using the following webpage: http://www.saao.ac.za/~sbp/Mar.html

2. The plots above indicate when the eclipses occur, but visibility windows should be checked with the SALT Visibility Tool.
3. Provide at least three different times per filter for which the observations can be attempted (in case of clouds).

Target options (select one from this list):
WW Hor
J0242-2802
HY Eri
V895 Cen
V1309 Ori
V1432 Aql
MN Hya
UZ For
V2301 Oph

Potentially useful references:
Use SIMBAD to find out about the selected objects (http://simbad.u-strasbg.fr/simbad/)
Warner, B. (2003), in *Cataclysmic Variable Stars*, Cambridge Astrophysical Series Vol 28, Chapter 6, p. 307.
Cropper, M. (1990), *The Polars*, Space Science Reviews, 54, 195.

#5: Wavelength Dependency of Spin Modulations in Intermediate Polars

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Intermediate Polars (IPs, sometimes also referred to as DQ Herculis stars) are binary stars consisting of a moderately strong magnetic field white dwarf accreting gas from a red dwarf companion star. Unlike their "cousins", the Polars, IPs are thought to have weaker field strengths, which is why their spin and orbital are not synchronized, as in Polars. Orbital periods are typically 2-4 hours and spin periods typically 10-30 min.

Little is known about the wavelength dependency of the light modulation in IPs on the spin period, thought to arise from varying aspects of the extended accretion regions. Most IPs are thought to be accreting from a disk of material orbiting the white dwarf, while some are probably diskless systems, where accretion occurs directly into the magnetosphere with the flow then channeled along field lines.

Tasks:
1. Review what is known about the reasons for the spin periods detected in IPs
2. Write an observing proposal to study the wavelength behaviour of the spin period in a selection 2 IPs, chosen to be one of *any* of the following:
    a. a potential discless accretor
    b. a recently identified hard X-ray IP from the INTEGRAL satellite
    c. an IP with a shorter than average spin period
    d. an IP thought to be a relatively high inclination system
    e. an IP visible in the period June-September
    f. an IP visible in the period November-February

Hint:
Check out Koji Mukai's Intermediate Polar website: http://asd.gsfc.nasa.gov/Koji.Mukai/iphome/iphome.html
Use SIMBAD to find out about the selected objects (http://simbad.u-strasbg.fr/simbad/)

Potential useful references:
Hellier, C. (1996), The Intermediate Polars, in *Cataclysmic variables and related objects*. Astrophysics and Space Science Library; Proceedings of the 158th colloquium of the International Astronomical Union (IAU); held at Keele; United Kingdom; June 26-30; 1995; Dordrecht: Kluwer Academic Publishers; |c1996; edited by A. Evans and Janet H. Wood, p.143.
Patterson, J (1994), Publications of the Astronomical Society of the Pacific, 106, 209

#6: Whole Earth Telescope Observations of a Pulsating White Dwarf

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Through a coordinated network of world-wide observatories, i.e. the Whole Earth Telescope (WET), we propose to undertaken SALT observations over a period of 5 nights in support of this campaign during a week of dark moon period in April 2009. We have chosen April for this WET run because it allows us to optimize coverage for two object, EC14012-1446 (our main target) and PG1159-035 (our secondary target). Ideally observations of both targets may be possible in a given night.

Recent advances have been made in pulsation theory to empirically determine the physical properties of convection in a pulsating hydrogen atmosphere white dwarf stars (DAV). Convection remains one of the largest sources of uncertainty in our understanding of stellar physics, leading to significant age uncertainties in massive stars (~20%, Di Mauro 2003). Convection is also the single largest uncertainty in determining the temperatures of pulsating white dwarfs (e.g. Bergeron et al. 1995). This is important since we use our knowledge of white dwarf interiors to calibrate white dwarf cooling sequences, which in turn provide accurate estimates for the ages of individual white dwarfs (Ruiz & Bergeron 2001) and the age of the Galactic disk (Winget 1987).

Applying a technique introduced by Montgomery (2005), we can use observed nonlinear pulse shapes of pulsating white dwarfs to directly probe the nature of their convection zones. These WET observations will hopefully provide light curves that, through period analysis will provide information on the pulse shapes. Although the individual SALT runs will only be ~1 h in length, the high S/N data may help to detect the presence of low amplitude modes and even the long searched for radial modes, with periods of ~seconds.

Tasks:

1. Review what is known about both stars EC14012-1446 and PG1159-035 and how the WET, and specifically the SALT, observations will improve our understanding.
2. Select the appropriate instrument and configuration to conduct the SALT observations in support of the WET campaign.
3. Select the appropriate dates for the observations
4. Complete the observing proposal, including finding charts, and submit it

Hint

Use Aladin (http://aladin.u-strasbg.fr/AladinPreview) and/or SIMBAD (http://simbad.u-strasbg.fr/simbad/) databases to find out about these objects.

Potentially useful background Reference(s):

Bergeron, P. et al. 1995, Astrophysical Journal, 449, 258
Di Mauro et al. 2003, Astronomy & Astrophysics, 404, 341
Montgomery, M. H., 2005, Astrophysical Journal, 633, 1142
Ruiz, M. T. & Bergeron, P. 2001 Astronomical Journal, 558, 761
Winget, D. E. et al. 1987 Astrophysical Journal, 315, 77

#7: Probing the Atmosphere of Pluto through an Occultation Observation

Dr Amanda Gulbis, SAAO
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For this exercise we must pretend that the year is 2007! On 14 June 2007, Pluto is predicted to "occult" a bright (V ~ 16) star at ~01:27 UTC.

Recent studies (Elliot *et al*. 2003; Sicardy *et al*. 2003) have shown that between 1988 and 2002 Pluto's atmospheric pressure has increased drastically. More recent data (Young *et al*. 2008; Elliot *et al.* 2007) indicate a general stability between 2002 and 2006. Some models predict that the pressure might continue to increase, but those models are largely dependent on unknown parameters. This is mainly a seasonal effect predicted by Hansen and Paige (1996), which dominates the vapor-pressure equilibrium between the primarily N_2 atmosphere and the surface ice. As Pluto recedes from its 1989 perihelion, deeper into the outer solar system, we anticipate its atmosphere will collapse back into ice sometime between now and the year 2020.

We plan to create a light curve during the predicted occultation time using SALT images of the candidate star and a comparison. To allow calibration, we request a sufficient amount of time to image the star and Pluto when they are well separated before and after the event. These proposed occultation measurements take place in the context of the *New Horizons* space mission, launched in 2006 and scheduled to fly by Pluto in 2015. The recent discovery of Pluto's two smaller moons, Nix and Hydra (Weaver *et al.* 2006), suggest the possibility that the Pluto system may possess tenuous rings created from Kuiper Belt debris that may also be detectable via this stellar occultation observation.

Tasks:

1. Review our knowledge about Pluto and how stellar occultations can provide information about its atmosphere and system.
2. Select an appropriate SALT instrument and configuration to optimize the observation.
3. Write a SALT observing proposal for the occultation event and submit it.

Hints:

See webpages http://occult.mit.edu/research/occultations/Pluto/P468/index.html and http://www.lesia.obspm.fr/perso/bruno-sicardy/14_jun_07/index.html for independent predictions of the occultation path.

References:

Elliot, J.L. et al. 2003, Nature, 424, 165-168
Elliot, J.L. et al. 2007, Astronomical Journal, 134, 1-13
Hansen and Page 1996, Icarus 120, 247-265
Sicardy, B. et al. 2003, Nature, 424, 168
Weaver, H.A. et al. 2006, Nature, 439, 943-945
Young, E.F. et al. 2008, Astronomical Journal, 136, 1757-1769

#8: Photometric properties of H I shells in the Magellanic Clouds

Dr Sudhanshu Barway, SAAO
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The Small Magellanic Cloud (SMC) is an irregular dwarf galaxy that is in orbit around the Milky Way galaxy, visible only from the southern hemisphere. It is roughly 60 kpc distant, making it an excellent source to study the interstellar matter (ISM) and star formation in nearby galaxies. High-resolution neutral hydrogen (H I) maps of the SMC have revealed a complex system of more than 500 "holes" surrounded by shells of higher density. Such shells are common in gas-rich galaxies, and have been catalogued in the Milky Way as well as in several nearby spiral and irregular galaxies and the Large Magellanic Cloud (LMC). There are over 500 shells and super-shells in the SMC, five times more than found in the much more massive LMC. The rich population of apparently (dynamically) young shells in the SMC provides us with an excellent statistical sample to re-address some of the basic questions related to the origin and evolution of shells and super-shells in gas-rich galaxies, which probably point towards a recent global burst of star formation in the SMC.

The Large Magellanic Cloud (LMC) at distance of 50 kpc, is also an excellent object to study supergiant shells. Because of its proximity, it is possible to study in detail the physical structure of supergiant shells, and it is also possible to resolve their underlying stellar content in order to determine their formation mechanism. Nine supergiant shells (SGS) have been optically identified in the LMC. Among the nine supergiant shells of the LMC, LMC 2 has been extensively studied because it appears to have the most coherent shell structure and has the highest X-ray surface brightness of all known LMC supergiant shells. LMC 4 is also of special interest because it is the largest.

The H-alpha shell, LMC 4, consists of diffuse filaments and bright H II regions and coincides with a remarkable H I hole. To date, various formation mechanisms for LMC 2 and LMC 4 have been suggested and are still under discussion.

We propose to study photometric properties of these supergiant shells in the SMC and LMC with SALT. We will obtain mosaic images of SMC, LMC 2 and LMC 4 in various filter bands available with SALT to get colors and hence information on star formation of these H I shells. Assuming that the observed H I structures in the SMC and LMC are driven by star formation, we would expect to find some correlation between the occurrence and properties of shells and massive star formation activity. Further, we will use these observations with the multi-band data (such as radio) available in literature to investigate the nature of H I shells with the help of VO tools.

Tasks:

1. Choose one of the following: SMC, LMC 2 or LMC 4.
2. Identify the super shells for your object from archive images.
3. Choose the suitable instrument, filter set and settings for the instrument.
4. Estimate the optimal observing period for your object.
5. Estimate needed exposure times in various bands to reach appropriate S/N.
6. Estimate the number of pointing to obtain an entire mosaic of your object with your settings.
7. Use PIPT tool to fill out the observing specifications that you have determined and submit it.

References:

Hatzidimitriou, D. et al. 2005, Monthly Notices of the Royal Astronomical Society, **360**, 1171
Points, S. D. et al. 1999, Astrophysical Journal, **518,** 298.
Yamaguchi, R. et al. 2001, Astrophysical Journal, **553**, 185.

#9: Observing comet 103P/Hartley 2 in support of the EPOXI mission

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After the *Deep Impact* mission, in which a projectile was smashed into the surface of comet 9P/Tempel 1 and the resulting plume of gas and debris were studied, the same flyby spacecraft is continuing on a new mission called *EPOXI*. The *EPOXI* mission includes flying past the nucleus of comet 103P/Hartley 2 on 04 November 2010.

Deep Impact determined the spin period of 9P/Tempel 1 to unprecedented accuracy. However, subsequent comparison with the period inferred from high quality *Spitzer* and *Hubble Space Telescope* indicated a drift in the spin rate of 0.015 days. The change in the spin rate has lead to increased knowledge about cometary activity, surface fluidization and transport, and the interior of the comet. Detecting the change in the rotation period was dependent upon both the long baseline in time and the high precision from a careful ground- and space-based observing strategy in combination with the spacecraft data. The size of the 103P/Hartley 2 nucleus has been estimated from infrared observations, but we know virtually nothing about its rotation properties. In order to understand the active cometary phenomena that are observed at high resolution during the *EPOXI* flyby, we must establish the comet's rotation period and provide a measurement by which to measure changes in the spin rate.

We propose to use SALT for an imaging investigation of 103P/Hartley 2. We plan to determine its rotation to a level of 20% accuracy during the comet's last opposition prior to the *EPOXI* encounter. Because the object is faint, we require dark time. We are proposing to additional telescopes in order to have full coverage of the rotation period; however, SALT is the largest and should provide the highest signal-to-noise ratio (SNR). We require SNR > 10, which could be difficult to achieve using smaller telescopes, especially if this object is a fast rotator.

Tasks:

1. Review the information we know about comet 103P/Hartley 2 and describe what can cause changes in the spin rate of a comet.
2. Select the appropriate observing dates and times.
3. Select the instrument, settings, filter(s), and exposure times required to reach the scientific needs described above.
4. Use the PIPT to create and submit a proposal.

Potentially useful references:

Groussin, O. et al. 2004, Astronomy & Astrophysics, 419, 375
Lamy, P.L. et al. 2007, Icarus, 187, 132
Lisse, C.M. et al. 2007, Astrophysical Journal, 625, L139
Snodgrass, C. *et al.* (2008). MNRAS, 385,737
Weaver, H.A. et al. 1994, Astrophysical Journal, 422, 374