NORDIC OPTICAL TELESCOPE

Strategy Meeting, Nov. 8-10, 2006

Group Reports

NORDIC OPTICAL TELESCOPE

Strategy Meeting, Nov. 8-10, 2006

Title of Research Group/Project: GL time delays

Science field: Cosmology and the distant Universe

Affiliation: Institute of Theoretical Astrophysics, Univ. of Oslo, Norway

Contact person: A. O. Jaunsen (ajaunsenastro.uio.no)

Outline of Research Plan for CNO and NOT:
The classical use of measured time delays has been to provide independent estimates of the expansion rate of the Universe (H_0) and the cosmological constant (Λ). The time delays are also unique probes of the dark matter distribution in (high-z) galaxies and can shed light on the slope of the DM distribution profile. What ever the cause, it is essential to build a representative sample of time-delays.

Building upon our previous successful experience with measuring time delays we have initiated a fresh program to monitor new gravitational lens systems with a very high sampling rate (in many cases daily). It is collaboration between the DARK/NBI (J. Hjorth) and ITA. The goal is to double the present number of time delays to accuracies approaching the limitations in the modeling (typically $< 5\%$). The main source of target selection is the Sloan Digital Sky Survey (SDSS). The project is already underway and we foresee a continuation well in to the proposed CNO-era.

Estimated observing time needed 2007-2011:
200h per year, needed to monitor 2 GLs on a nightly basis. The exact figure will depend on the brightness and chosen observing frequency of each target. The adapted frequency will depend on the expected time delay from modeling, for instance systems with time delays of more than 2 months will normally not be observed on a nightly basis.

Optimum CNO telescope(s) for your research:
Data homogeneity is a very important provision in dealing with monitoring data and the analysis needed to estimate a time-delay. It is therefore suiting for this project to use only one telescope of excellent optical quality and providing flexible scheduling such that the targets in question can be observed at the optimal time. The 2.5m NOT is no doubt the most suitable telescope for our project providing a high level of flexibility in scheduling. A backup camera in the adaptor which can be inserted in the optical path with great ease independent of the instrument mounted in the Cassegrain focus.

Instrumentation needed or desirable:
We require a CCD camera of good quality and sensitivity, such as the present ALFOSC camera. StanCam will be used as a backup camera, when ALFOSC is not mounted.

Scheduling, observatory services needed:
Since GL monitoring relies on regular and in some cases nightly observations we are dependent on the help of visiting astronomers or staff to perform the observations.

Any special constraints:

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Strategy Meeting, Nov. 8-10, 2006

Title of Research Group/Project:
Observation Cosmology/Search and follow-up of nearby supernovae

Science field: Cosmology and the distant Universe

Affiliation: Stockholm University, Physics Department & Stockholm Observatory

Contact person: Ariel Goobar (ariel@physto.se)

Outline of Research Plan for CNO and NOT:

Low redshift Type Ia supernovae, $z < 0.1$, play two important roles for the understanding of dark energy: as an anchor for the Hubble diagram and as an indicator of possible systematics. The intrinsic degeneracy in cosmological distances implies that many hundred well studied nearby supernovae are needed to make full use of the high-redshift missions planned at large ground based telescopes and space missions. This conclusion is strengthened upon including velocity flow and magnitude offset systematics and a potential supernova population drift (evolution). In addition, studies of non-Ia supernovae are important to adress potential contamination issues with the high-z Hubble diagrams.

We propose to use the larger FOV telescopes at CNO to search for SNe and for NOT as a key instrument in their spectroscopic identification.

Estimated observing time needed 2007-2011:
A detection of ∼50 SNeIa/year at with $< z >\sim 0.05$ would require s survey of at least 300 sq.deg/year to a magnitude limit of $B \sim 20$ with a "rolling search" technique, i.e. repeat imaging of the same field every few nights. Upon trigger, a) multi-band observations would be required b) spectroscopic identification.

Optimum CNO telescope(s) for your research:

The SN search could be combined with a more general search for optical transients, e.g. optical counterparts to GRBs. The figure of merit is the *etendu* of the instrument, i.e. $A\Omega$. Most likely INT or WHT will host the best instruments for the search, while NOT is likely to be well-suited for spectroscopic follow-up and TNG for NIR follow-up.

Instrumentation needed or desirable:

Optical Imaging: large FOV with stable PSF over entire field
NIR imaging: high efficiency, as the sky background is high
Spectroscopy: low resolution, low fringing, high accessibility.

Scheduling, observatory services needed:

Spectroscopic follow-up would be executed almost every night, i.e. high flexibility in instrument switching.

Any special constraints:

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Strategy Meeting, Nov. 8-10, 2006

Title of Research Group/Project: The variable/transient Universe

Science field: Cosmology and the distant Universe

Affiliation: DARK Cosmology Centre, Niels Bohr Institute

Contact person: Johan Fynbo, jfynbo@dark-cosmology.dk

Outline of Research Plan for CNO and NOT: The transient Universe is gaining more and more importance for the study of cosmology and the distant Universe. The last decade has seen tremendous progress in cosmology, which to a very large extent has been achieved through the search for and monitoring of supernovae (SN) of type Ia. This has resulted in the current "Dark energy Paradigm". Also in the last decade the study of Gamma Ray Bursts (GRBs) and their afterglows has experienced a revolution. With the currently operating *Swift* satellite several GRBs per week are routinely localized to arcsec precision a few minutes after the bursts. This has allowed a new extremely powerful study of star-formation in the distant Universe extending all the way back to the end of the Dark ages.

In the future there is every reason to expect that the study of the transient Universe will remain at the forefront of observational cosmology. We need to understand what dark energy is, and this requires 2nd generation, much larger SN Ia surveys. To capitalize the potential of GRBs the task is to build statistically useful samples. Furthermore, the quest is to make instrumental advances that will allow us to push beyond redshift 6, where optical instruments fall short. The GLAST satellite will search for GRBs possibly of other types with much higher photon energies. On a slightly longer timescale, gravitational wave detectors may open up for a completely new window to the transient Universe. With the NOT/CNO we wish to play a major role in this research in the next 5 years.

We also wish to use the NOT for monitoring of variable objects (e.g., lensed QSOs) and for exploratory/pilot projects which may eventually be conducted at larger facilities once NOT has provided a proof of concept. The increased flexibility in instrument availability and scheduling required for studying the transient Universe will allow such programs to be conducted in a more straigtforward manner.

Parts of the proposed NOT research program will be conducted in collaboration with groups in Oslo, Stockholm, and Reykjavik. Parts of the proposed CNO research will be conducted in collaboration with groups in Leicester, Hertfordshire, and Amsterdam.

Estimated observing time needed 2007-2011: 2 months per semester?

Optimum CNO telescope(s) for your research: The NOT equipped with (nearly) always available optical, near-IR cameras and spectrographs with a rapid response mode would be highly desirable for our purposes. In addition we would ideally wish to have access to a larger aperture telescope (WHT or better GrandeCan) for spectroscopy of faint targets (GRB host galaxies, distant afterglows and SN).

Instrumentation needed or desirable: Standby optical, near-IR cameras and spectrographs. A permanently mounted NOTCAM and a standby FOSC would be a solution.

Scheduling, observatory services needed: A rapid response mode, e.g., similar to the one implemented at the VLT, is needed. Moreover, continued steps towards larger, quick-turnaround service observing programs will give NOT a competitive edge. Alternatively, very large amounts of observing time (of order 100 nights/year) can be allocated to consortia who will provide visiting observers and schedule allocated time internally within the consortium.

Any special constraints:

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Strategy Meeting, Nov. 8-10, 2006

Title of Research Group/Project: GRBs and Cosmology

Science field: Cosmology and the distant Universe

Affiliation: Science Institute, University of Iceland

Contact person: Gunnlaugur Björnsson, gulli@raunvis.hi.is

Outline of Research Plan for CNO and NOT: Our main focus will be on Ly-α emission from GRB host galaxies and their environment. The NOT has already proven suitable for such observations. Access to larger telescopes within CNO, such as WHT, will allow for studies of fainter hosts and high redshift ($z > 3$).

Estimated observing time needed 2007-2011: 8 nights/year for 5 years = 40 nights

Optimum CNO telescope(s) for your research: Having access to a 4m telescope (WHT) would allow us to study the Ly-α emission of fainter GRB hosts with $z > 3$.

Instrumentation needed or desirable: ALFOSC

Scheduling, observatory services needed: No special service is needed. We prefer visitor mode for our observations. For this type of work grey or dark time is needed.

Any special constraints:

NORDIC OPTICAL TELESCOPE

Strategy Meeting, Nov. 8-10, 2006

Title of Research Group/Project: Supernova monitoring in ~ 100 galaxy cluster fields

Science field: Cosmology and the distant Universe

Affiliation: University of Oslo

Contact person: Håkon Dahle (hdahle@astro.uio.no)

Outline of Research Plan for CNO and NOT:

The opportunity for optical imaging with a moderately wide field at the NOT using FRED, creates the possibility for designing an ambitious large observational program, combining detection of new supernovae with deep imaging of galaxy clusters. Among the questions which could be answered by such a survey are: What is the nature of the dark energy that accelerates the expansion of the universe? Can some type II supernovae be used as cosmic yardsticks, at higher redshifts than the type Ia supernovae that have been studied so far? How do the abundances of different types of supernovae vary as a function of cosmic time, and of local environment? What is the assembly history of galaxy clusters, and what fraction of the baryonic matter in clusters is contained in stars in the diffuse intra-cluster component? How do galaxies evolve as a function of local environment, and how is the star formation in galaxies shut down as they fall into the densest regions of a galaxy cluster? Can a future discovery of multiple images of a gravitationally lensed supernova provide a more accurate measurement of the current expansion rate of the universe than current monitoring of gravitationally lensed quasars?

Interestingly, all these questions can be addressed *using the same data set*, from a carefully designed large survey of massive clusters of galaxies. By properly adjusting the cadence of such a survey, it could e.g. be used to detect ~ 200 supernovae per year (in front of, inside, and behind the clusters), of which perhaps one could be split into multiple images by strong gravitational lensing, and many more would be amplified by gravitational lensing, significantly enhancing the detection rate of distant supernovae.

The combined images that would be accumulated over time would provide very deep imaging of ~ 100 galaxy clusters. By spreading the imaging over different passbands, approximate distances can be determined for a large fraction of all galaxies in the fields through photometric redshift estimates. This would provide precise mass measurements of the clusters via weak gravitational lensing and would also be useful for various studies of the physical properties of clusters mentioned above. For studies of background sources, clusters act as giant "natural telescopes", magnifying and amplifying faint distant objects that might otherwise be unobservable. Observations of "standard candle" type Ia supernovae behind clusters will help refine the cluster mass distribution by probing the magnification along particular lines of sight.

Estimated observing time needed 2007-2011:

18 nights/semester for 3 years for monitoring, plus time for spectroscopic followup observations for classification and redshift determination of supernovae (fainter targets will require a 8-10m class telescope such as GTC).

Optimum CNO telescope(s) for your research:

NOT, as it offers the greatest flexibility for monitoring-type observations.

Instrumentation needed or desirable:

FRED. A FOV of this size is needed to probe a sufficiently large range of radii in the clusters, to ensure a competitive detection rate of supernovae, and for weak gravitational lensing measurements and studies of cluster properties over a range of environments.

Scheduling, observatory services needed:

The program can be conducted within a normal scheduling cycle. The equivalent of three (not necessarily consecutive) nights are needed every month, for the continued monitoring of a sufficient number of fields.

A modest amount of additional ToO or service time might be needed for photometric monitoring of particularly interesting supernovae and other variable sources.

Any special constraints:

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Strategy Meeting, Nov. 8-10, 2006

Title of Research Group/Project: Cosmology with galaxy clusters.

Science field: Cosmology and the distant Universe

Affiliation: University of Oslo

Contact person: Håkon Dahle (hdahle@astro.uio.no)

Outline of Research Plan for CNO and NOT:

The main purpose of this program is using galaxy clusters to probe dark energy and constrain cosmological parameters related to structure formation. Another goal is to better understand the physics of galaxy clusters, from combined studies of the properties of visible galaxies, the dark matter distribution (from gravitational lensing) and hot intra-cluster gas, from X-ray observations and observations of the Sunyaev-Zel'dovich (SZ) effect.

Previously, NOT has been used for gravitational lensing mass measurements of a complete sample of the 35 most X-ray luminous clusters within a volume of 2 Gpc^3. These observations have provided constraints on the present-day amplitude of density fluctuations in the Universe which are competitive with (and complementary to) constraints from other types of observations, and consistent with recent constraints from the 3-year WMAP data. The results have also been used, together with the 3-year WMAP data, to derive a "robust" cosmological limit on the neutrino mass of $M_\nu < 1.40$eV (95% C.L.; since this limit is based on mass measurements from gravitational lensing, it does not depend on making any assumptions about the relation between dark and luminous matter).

By expanding the current data set in three different ways, competitive – and unique – constraints can also be derived for dark energy, including the ability to distinguish between models that are degenerate in other data sets (e.g., observations of high-redshift supernovae): Firstly, the lensing mass measurements can be improved by obtaining approximate redshift measurements of the lensed background galaxies, through photometric redshift measurements from multi-band imaging. Secondly, using wide-field imaging data for the clusters, the gravitational lensing effect can be measured over a wider range of radii, reducing statistical and eliminating remaining systematic uncertainties in the mass estimates. Finally, by expanding the range of redshift covered by the cluster sample, new constraints can be placed on the of growth of structures as a function of cosmic time, yielding estimates of the equation of state of dark energy. A different probe of dark energy comes from a purely geometrical measurement of how the strength of the lensing effect depends on source redshift. Combining these two will enable tests of modified gravity models as an explanation for the accelerated expansion of the universe.

In addition to measuring the primordial fluctuations in the Cosmic Microwave Background, ESA's Planck satellite will detect $> 10^3$ galaxy clusters through the SZ effect. The redshifts of these clusters cannot be determined directly from Planck data, and need to be estimated, (from broadband photometry in two or more optical/NIR passbands, enabling the identification of the "red sequence" formed by early-type cluster galaxies) to provide competitive constraints on dark energy and other cosmological parameters.

Estimated observing time needed 2007-2011:

- 70 nights for broadband optical imaging of (~ 100) X-ray selected clusters. If FRED is available at NOT, this project may be combined with the project "Supernova monitoring of ~ 100 galaxy cluster fields", simply by splitting the observations of each cluster into multiple epochs.

- 50 nights (2010–) for optical/NIR imaging of ~ 500 SZ-detected clusters in the northern hemisphere from Planck.

Optimum CNO telescope(s) for your research:

Field size is an important requirement for weak gravitational lensing measurements. However, beyond a radius of ~ 10' there is little to gain in the accuracy of cluster lensing mass measurements, due to noise from unrelated large-scale structures along the line of sight. An imager with a FOV ~ 20' would thus be well suited for this project, favouring NOT (with FRED) and/or WHT/PFIP.

Instrumentation needed or desirable:

Gravitational lensing studies: Optical imager with ~ 20' field of view and good, uniform image quality across the field. Standard $UBVRIz$ filters.

Verification/redshift estimates of Planck-selected clusters: Optical + NIR broadband imaging with FOV similar to ALFOSC and NOTCam, or larger.

Scheduling, observatory services needed:

The program can be conducted in normal visitor mode.

Any special constraints: None

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Strategy Meeting, Nov. 8-10, 2006

Title of Research Group/Project:
The co-evolution of galaxies and supermassive black holes

Science field: Cosmology and the distant Universe

Affiliation: ITA, University of Oslo

Contact person: Margrethe Wold

Outline of Research Plan for CNO and NOT:

One of the most important challenges facing modern cosmology concerns the formation and evolution of galaxies. In the last few years, the astronomical community has come to realize that supermassive black holes may play a crucial role in galaxy formation, through feedback processes regulating both black hole growth and star formation. Black hole growth and galaxy evolution is therefore intimately linked as is evident from the tight correspondence between the mass of the central black hole and the velocity dispersion of stars in galaxy bulges (the M-sigma relation). The relation between black hole mass and stellar velocity dispersion is the single most important tool we have for studying how galaxies and black holes co-evolve.

In order to study the co-evolution of black holes and galaxies we need to determine 1) black hole masses and 2) stellar velocity dispersions. To measure black hole masses is extremely challenging even for large telescopes because the sphere of influence of the black hole needs to be resolved (the region where the black hole potential dominates over the bulge potential), and this is typically < 0.1 arcsec, even for local galaxies.

However, black hole masses can be measured by utilizing temporal resolution instead via the reverberation mapping technique. This is *the only direct method* which yields information about smaller spatial scales that cannot be resolved spatially. Advancement in black hole research over the next decade is likely to come from reverberation mapping campaigns. This is because 1) the sample of nearby galaxies for which direct gas/stellar dynamical methods are applicable has already been exhausted by HST/STIS, and 2) direct gas/stellar dynamical methods, even with the next generation of extremely large telescopes, will be extremely challenging. (Even at modest $z = 0.1$, the radius of the black hole sphere of influence in a typical galaxy is ≈ 6 mas. For comparison, the diffraction limit of a 40m telescope in the K-band is 14 mas). Black hole studies by reverberation mapping is therefore an area where smaller telescopes are competitive, and will continue to be.

The reverberation technique requires monitoring, both photometrically and spectroscopically, and is applicable to AGN with emission lines. The lines which are typically monitored are Hα and Hβ. Low- to medium-resolution is required for this. The photometric monitoring is performed in the optical.

For determining stellar velocity dispersions of AGN host galaxies, medium-resolution optical and NIR spectroscopy is used to target Fe absorption lines longward of the MgIb complex at $\approx$5100 Å, or the CaII triplet at 8500–8660 Å. AGN contamination is dealt with by including AGN templates in the spectral fitting.

Estimated observing time needed 2007-2011:

20–30 nights

Optimum CNO telescope(s) for your research:

Photometric monitoring: For photometric monitoring the NOT is optimal because it requires that the observations are done by staff or visiting astronomers. NOT is preferred as it is user-friendly for visiting astronomers and has well-developed routines for monitoring and ToO programmes.

Spectroscopic monitoring: For the brighter targets, NOT is preferred for the reasons given above. For fainter objects, WHT and/or TNG is better because of the larger light-collecting area.

Absorption-line spectroscopy: For velocity dispersion measurements, WHT and/or TNG is preferred because of the larger light-collecting area.

Instrumentation needed or desirable:

Photometric monitoring: any optical imager mounted on the telescope; ALFOSC, MOSCA and StanCam for the NOT.

Spectroscopic monitoring: For the brighter targets at the NOT, ALFOSC is preferred. For fainter targets ISIS at WHT or Dolores at TNG.

Absorption-line spectroscopy: optical and NIR spectroscopy with Dolores and NICS on TNG. ISIS on WHT, and LIRIS if upgraded to medium resolution.

Scheduling, observatory services needed: The possibility of service mode observing, executed either by staff or visiting astronomers. Reverberation mapping campaigns require data taken every 2nd or 3rd night over a period of 2–3 months.

Any special constraints: No.

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Strategy Meeting, Nov. 8-10, 2006

Title of Research Group/Project: Tuorla Observatory AGN group

Science field: Cosmology and the distant Universe

Affiliation: Tuorla Observatory
University of Turku
Väisäläntie 33
FIN-21500 Piikkiö
Finland

Contact person: L. O. Takalo, takalo@utu.fi

Outline of Research Plan for CNO and NOT:

We plan to continue our AGN variability studies with special emphasis on polarization. We have currently two active programs that will run until at least end of 2008. Both are aimed at determining the emission locations of various variability phenomena in AGN: 1) the microvariability study aims at determining the source of fast intranight variations using polarization as an additional tool to infer the primary emission mechanism. This program has been made possible by the windowed photometry mode of ALFOSC (modified to polarimetry) that is offered by the NOT. 2) The BL Lac object OJ 287 has regular outbursts at $\sim$12 year intervals, which has been explained as the result of a binary black hole system with a 12-year period. The models predict the next outburst to occur in 2006-07 and we are currently running an optical monitoring program to check the predictions. Here we are also using polarization to infer the primary emission mechanism (thermal vs. synchrotron) of the outbursts, benefiting greatly by the good polarization capabilities of the NOT.

The gamma-ray satellite GLAST will be launched in 2007, undoubtedly creating many follow-up studies. GLAST is likely to detect 3000 new gamma-ray emitting blazars, which is a huge leap from the $\sim$70 sources known today. It is possible that new blazar populations are discovered, and we are interested in identifying the new gamma-ray sources and studying the host galaxies of blazars, which can then be used to infer e.g. the central black hole mass and study the cosmic evolution of blazars. The generally good seeing at the NOT makes it one of the best places in the world for these kind of studies. For high-redshift sources highest possible angular resolution is critical and we would like to study closer the suitability of lucky imaging for this project.

Estimated observing time needed 2007-2011:

About 14 nights/year.

Optimum CNO telescope(s) for your research:

Our first choices are the NOT and the WHT. We need fast photopolarimetric capabilities and good seeing. NOT has all of these already and if LuckyCams become common user instruments, they can be used at both sites for fast photopolarimetry and possibly in host galaxy studies. With the WHT we would benefit further from the larger aperture.

Instrumentation needed or desirable:

Polarimetric capabilities, especially fast photopolarimetry is important to us, i.e. we need a detector with a fast readout (either windowed readout or a L3CCD). For us it would be also desirable that LuckyCams became common user instruments. Intermediate-resolution spectroscopy at the WHT (to identify the GLAST blazars) is also likely to be needed.

Scheduling, observatory services needed:

For the long time monitoring projects (e.g. OJ 287) we need service type observing, so maintaining this mode would be desirable to us.

Any special constraints:

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Strategy Meeting, Nov. 8-10, 2006

Title of Research Group/Project: Secular evolution of galaxies.

Science field: Cosmology and the distant Universe (actually low z gal.)

Affiliation :University of Oulu / Astronomy Division

Contact person: Eija Laurikainen (eija.laurikainen@oulu.fi)

Outline of Research Plan for CNO and NOT:

We study the role of secular evolutionary processes in the galaxy evolution, and particularly, how bars are involved to these processes. We focus mainly to a sample of nearly 200 early-type disk galaxies, distributed to both hemispheres. When combined with the Ohio State University Bright Galaxy Survey (OSUBGS) for spirals, this is expected to form a very useful database to tackle our goals, which are:

(1) To study how robust are bars when evolved over time.

(2) To test the theoretical models where angular momentum transfer between bars and halos is expected to lead to secular evolution in galaxies.

(3) To study how these processes might affect the Hubble sequence and in particular, to verify how the morphological and kinematical properties of bars, bulges and ovals in galaxies fit to the present hierarchical evolutionary picture of galaxies.

Yet observationally unresolved questions are for example: (1) do S0s have massive halos? (it is only recent instrumental development that has made possible to study this issue), or (2) are the bulges in early-type disk galaxies supported by galaxy rotation or stellar velocity dispersion? (3) There is also a controversy between theory and observations in a sense that bars in early-type galaxies are found to be fast, although theoretically they are expected to be slowly rotating systems, provided that these galaxies have massive dark matter halos. To make most efficient use of our observations, we have developed sophisticated decomposition and Fourier analysis methods, and use dynamical simulations for theoretical interpretations.

Estimated observing time needed 2007-2011: 40 nights

Optimum CNO telescope(s) for your research:

NOT, WHT and TNG are excellent telescopes for the observations of our project in the northern hemisphere, whereas in the south VLT/NTT at ESO are used. These three telescopes are large enough, high image quality is guaranteed by adaptive optics, and the available instrumentation is well suited for our purposes. Particularly WHT is equipped with instruments specifically designed to study kinematics of early-type galaxies (PN.S, SAURON, OASIS). Presently for Finland NOT/CNO is the only alternative in the north.

Instrumentation needed or desirable:

The main instruments in La Palma used in our project are: NOTCam and ALFOSC at NOT, and LIRIS at WHT. Combining the observations of these telescopes with those made at ESO/NTT by us, altogether IR (and partly optical) deep images for 90 early-type disk galaxies have been made (Laurikainen et al. 2005, MNRAS, 363, 1319; Buta et al. 2006, AJ, 132, 1859; Laurikainen et al. 2006, astro-ph/0609343, in press).

In addition to the optical and near-IR images, also the following kinematical observations are required for the follow-up studies of our sample:

- PN.S(WHT) is the most efficient instrument developed so far to observe rotation curves of early-type galaxies. A similar instrument is palanned also to TNG. At ESO we are involved to a new 3D Fabry-Perot instrument project, which will make possible efficient observations of rotation curves also in the southern hemisphere.

- SAURON,OASIS(WHT): stellar kinematics of bulges. We are already collaborating with the SAURON group through a collaboration with Johan Knapen at IAC. At ESO SINFONY offers similar capabilities as SAURON.

- ISIS,LIRIS(WHT), Nics,LRS(TNG), NOTCam(NOT): long slit spectroscopy of stellar kinematics of bars and ovals (in the south time allocated at VLT for similar observations).

PN.S studies will probe dark matter halos in galaxies, and when combined with the 3D stellar kinematical observations, also whether the bulges are velocity dispersion or rotation supported. Multi-slit spectroscopy will complement the kinematical picture, as bar pattern speeds can be estimated, and the nature of multiple ovals, typical for S0s, can be investigated.

Scheduling, observatory services needed:

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Title of Research Group/Project: Studies of the stellar populations in the Milky Way and Local Group galaxies

Science field: The Milky Way and the Local Group

Affiliation: Lund Observatory, Uppsala Astronomical Observatory

Contact persons: S. Feltzing (sofia@astro.lu.se) & N. Ryde (nils@astro.uu.se)

Outline of Research Plan for CNO and NOT:

Several groups in the Nordic countries are currently active in the field of resolved stellar populations in the Milky Way and the Local group. This proposal is an attempt to summarize the telescope and instrumentation needs of these groups in Sweden.

Major research areas pursued by our groups include: Chemical evolution of the Milky Way, stellar physics using high-resolution spectroscopy and detailed modelling, the search for and abundance analysis of the most metal-poor stars of the Galaxy, and studies of the dwarf spheroidal galaxies in the Local Group. In an appendix we have collected longer science cases for each of these fields. Below follows a short summary of observational needs.

The origin and evolution of the Milky Way and its satellite galaxies provides an important test bed for our understanding of how galaxies form and evolve. Our research groups focus on providing the best available observational constraints to test models of formation and evolution of spiral galaxies. The primary observational methods we use are various types of spectroscopy for abundance analysis, complemented by photometric studies using dedicated systems such as the Strömgren system. In addition to observations in the visible, infra-red or near infra-red spectroscopy is a very promising field for certain projects. Here we would like to highlight the possibility to use guest instruments, e.g. PHOENIX.

We also see the CNO as an important training facility for young astronomers. It is becoming increasingly difficult to get hands-on observational experience at e.g. Paranal.

Estimated observing time needed 2007-2011:

Here we only comment on currently available instrumentation. As our projects are large we envision that beyond the current operational mode of the telescopes and with a CNO in place we would use the telescopes for a number of weeks per semester in total.

INT+WFC: 1–2 weeks per semester over the coming next years for continued studies of dSph galaxies, both currently known and newly found ones. Studies of the Milky Way stellar populations are also a possibility and could add a week or two per semester.

NOT+FIES/SOFIN: One run per year over the coming few years would exhaust most chemical evolution studies we plan to do and which are feasible with the NOT.

NOT+ALFOSC: Potentially study the metallicity distribution in one or two of the furthest away dSph galaxies. $\sim$ 2 weeks per year.

Optimum CNO telescope(s) for your research:

NOT+ALFOSC: Useful for follow-up observations of candidate metal poor stars (low-resolution spectroscopy and photometry).

NOT+FIES/SOFIN: Abundance studies of stellar streams for the brighter stars.

WHT+UES: *If UES recommissioned* studies of the galactic disks; follow-up work for brighter metal-poor stars; halo streams.

WHT+AF2/WYFFOS: Ca II triplet studies of other stellar systems (e.g. dwarf galaxies) for dynamic studies of matter distribution.

INT+WFC: Wide field imaging in e.g. Strömgren photometry for stellar populations both other galaxies and in the field in our own Milky Way.

GRANTECAN: *If available* this is the most competitive telescope for studies of the most metal-poor stars in our Galaxy and also the only telescope on La Palma which is suitable for spectroscopic abundance studies of Galactic globular clusters and Local Group galaxies.

TNG + Giano may be operational in a year or two. Useful for NIR studies of stellar populations and stellar abundances in the Milky Way and local group galaxies. Especially, explorations of metal-rich stars, and also studies of AGB star evolution and empirical studies of nucleosynthesis processes in different environments, would benefit.

Instrumentation needed or desirable:

The work on stellar populations and the history of the Milky Way and its satellite galaxies needs both spectroscopic and photometric facilities. *For details see above.*

Scheduling, observatory services needed: Some of the spectroscopic projects mentioned above are suitable for Service Mode observations.

Any special constraints: *None*

APPENDIX with science cases for our major research areas

Chemical evolution of the Milky Way:

The Galaxy is a large, complex entity and our current observational resources for high-resolution spectroscopy limit us to study mainly the stars that are closest to us. In the solar neighbourhood several different stellar populations overlap. These populations show different kinematic properties and it is therefore possible to, at least statistically, disentangle them.

A combination of kinematic information and abundance results based on high resolution spectroscopy has proved to be a very valuable instrument to disentangle the histories and properties of these various stellar populations. Edvardsson et al. (1993) provided one of the first such studies, subsequent investigations have shown the disk system to be very complex indeed (e.g. Bensby, Feltzing et al. 2003, A&A 410, 527 and 2004, A&A 415, 155). The important thing about all of these studies is that they adopt a differential methodology such that stars with different kinematic signatures are analysed and studied with exactly the same methods in the abundance analysis. This differential approach has been able to reveal intriguing differences between kinematically distinct groups, such as the thin and the thick disk.

Ongoing studies are starting to explore stellar populations that are not necessarily belonging to either the thick or the thin disk. For example a study of the Hercules stream shows it to have elemental abundance trends like the thick disk but a mean metallicity more like that of the thin disk (Bensby et al. 2006, in prep.). Elemental abundance studies using high-resolution spectroscopy of stars well beyond the solar neighbourhood is a developing area, recent results include the Bulge (which is not possible to study properly from La Palma) but also in situ thick disk studies (Feltzing et al. 2006, in prep.).

For this work we need access to both northern and southern hemisphere telescopes of 4–10 meter class equipped with high-resolution spectrographs. The smaller telescopes, e.g. NOT, may still be useful for some years for dedicated studies of specific stellar streams.

Furthermore, access to wide field imaging, such as e.g. the WFC on the INT, will be useful for statistical studies of e.g. the metallicity distribution functions of the various disk components at larger distances ($\sim$ 1–2.5 kpc). Such studies are complementary to e.g. the SDSS in that a photometric wide field survey is complete to a much higher degree than e.g. SDSS is. We are currently pursuing one such project (as a spin off from our dSph projects, see below) (Arnadottir, Feltzing et al., in prep.).

Stellar physics:

To extract the chemical information encoded in stellar spectra, the essence of the matter-light interaction taking place in stellar atmospheres has to be captured in a numerical model. In classical model atmospheres, far-reaching approximations like local thermodynamic equilibrium (LTE) and mixing-length convection are made. In the light of more sophisticated modelling (made possible by better atomic data and faster computers), these approximations are more questionable than ever. It is thus our ambition to lift these approximations one by one and thereby remove the biases they introduce to photospheric chemical abundances. Among the effects studied in recent years are hydrodynamical models of convection (Collet et al. 2006, ApJ 644, 121), departures from LTE (Korn et al. 2003, A&A 407, 691; Collet et al. 2005, A&A 442, 643; Mashonkina, Korn & Przybilla 2006, A&A, in press) and atomic diffusion (Korn et al. 2006, Nature 442, 657). All these affect chemical abundances of cool stars at a level that is relevant for cosmochemical studies. They become particularly important when analysing the chemical signatures of the first stellar generation (so-called Population III) in the spectra of halo stars. Efforts are also made to make the ESA cornerstone mission Gaia profit from these modelling advances.

While spectroscopic in-situ studies of the Galactic halo nowadays require 8–10 m-class telescopes for forefront research, this is not the case for photometry. For preselection of targets in e.g. globular clusters, we therefore need access to medium-size telescopes, also to confront and combine photometric results with spectroscopy.

Metal-poor stars:

The search for the most metal-poor stars of the Galaxy utilises a multitude of telescopes and observational techniques (see Beers & Christlieb 2005, ARA&A 43, 531, for a review). Current research interests in our groups that are of relevance for the mid- and long-term planning of the NOT and the CNO include the usage of 2–4 m-class telescopes to obtain photometry and low resolution ($R \simeq 2000$) spectroscopy for follow-up of candidate metal-poor stars identified in e.g. the Hamburg/ESO objective-prism survey (HES; Christlieb et al. 2003, Rev. Mod. Astron. 16, 191), in which members of the stellar group in Uppsala are involved.

However, for detailed abundance studies of the most metal-poor stars in the galactic halo, 8–10 m-class telescopes are required because these stars are faint: most of the currently-know stars at [Fe/H] < -3.5 dex are fainter than $B = 14$ mag. The two most heavy-element deficient stars currently known, HE 0107−5240 (Christlieb et al. 2002, Nature 419, 904), and HE 1327−2326 (Frebel et al. 2005, Nature 434, 871) were both found in the now mostly completed HES, which reaches down to $iB \simeq 17.5$ mag. Therefore, finding more stars with [Fe/H] < -5.0 dex will require a deeper survey limit and/or an extension of the covered sky area.

Members of the Uppsala group are involved in a new, deeper ($B \leq 19$) survey for metal-poor stars to be conducted with the Chinese 4 m LAMOST telescope, which is capable of obtaining spectra of 4000 objects simultaniously in a field of view having a diameter of 5 deg. The telescope is currently being built at Xinglong Station close to Beijing; i.e., in the northern hemisphere, which so far has been exploited for metal-poor stars only down to $B \sim 15.5$ by the HK survey of Beers et al. (1992, AJ 103, 1987). LAMOST is scheduled to have First Light in 2007, and it is expected to be fully operational in 2008.

GranTeCan equipped with an efficient Echelle spectrograph covering the optical wavelength region would be an ideal facility for obtaining high-resolution spectra of the metal-poor stars to be found with LAMOST, and hence getting access to GranTeCan has a high priority for us.

Local Group dwarf galaxies:

Dwarf galaxies in the Local Group provide excellent testbeds for our understanding of galaxy formation and evolution. Recent years have seen a surge in activity in this area. Several studies have looked at the kinematic properties of these objects and we now know that the dwarf spheroidal galaxies (dSph) are some of the objects in the Universe with the largest mass-to-light ratios. In addition, we now know something about the elemental abundance trends in these objects.

These galaxies are large on the sky (tidal radii range from a few arcmin up to 160 arcmin for Sextans) hence for photometric work wide field imagers are needed. The closest Milky Way companions are around 100 kpc away and hence their brightest red giants are easily reachable for spectroscopy with an 8–10 m-class telescope.

So far it is mainly the southern hemisphere dSph that have been studied (thanks to the VLT), but some of the most intriguing dSph are located in the Northern hemisphere, e.g. Draco and Ursa Minor, also several of the newly discovered dSph candidate galaxies are in this hemisphere. Currently only KECK has instrumentation that can obtain sufficiently good spectra to observe even the brightest of the giants in these galaxies.

The group in Lund has pursued studies of the northern dSph galaxies using Strömgren photometry. We are doing this in collaborations with groups in the U.K. who study the dark matter content of dSph galaxies (for a recent review of their work see e.g. Wilkinson et al. 2006, The Messenger 124, 25). The usage of Strömgren photometry has the advantage of easily distinguishing between foreground dwarf stars and red giants in the dSphs themselves. In addition we have shown that the metallicities obtained with this method for the red giant branch stars are very good (Faria, Feltzing et al. 2006, A&A accepted). For this work we need access to a wife field camera equipped with the Strömgren filters. The INT has such a set-up and it is that that we have used so far. Other wide-field possibilities would also be interesting provided that suitable filter systems can be obtained.

We are currently pursuing studies of the outer regions of the dSph galaxy Draco in order to find red giant stars that are members of Draco which may be used to trace the velocity profile at the edge of the dSph galaxy. The radial velocity observations would be done with AF2/WYFFOS on WHT. We are also pursuing studies of the newly detected dSph candidates (e.g. Hercules; see Belokurov 2006, astro-ph/0608448) to 1) find the members, and 2) derive metallicities.

There is much work yet to be done on the dSph. The highest priorities are 1) finding stars that are members of the dSph at large radii and obtain velocities for them to study the mass distribution; 2) obtain metallicity distribution functions over large areas of these galaxies to study their star formation histories; 3) obtain elemental abundances to study the chemical evolution.

For items 1 and 2 telescopes and instruments are available (INT, WHT, WFC, and AF2/WYFFOS) but for item 3 we would need access to GranTeCan equipped with a high-resolution spectrograph operational in the visual.

NORDIC OPTICAL TELESCOPE

Strategy Meeting, Nov. 8-10, 2006

Title of Research Group/Project:
Investigation of the Galactic Structure

Science field:
The Milky Way and the Local Group

Affiliation:
Institute of Theoretical Physics and Astronomy, Vilnius University, Vilnius, Lithuania

Contact person:
V. Straizys, straizys@itpa.lt

Outline of Research Plan for CNO and NOT:
CCD photometry in the eight-color StrömVil (Strömgren-Vilnius) photometric system makes it possible to obtain spectral types, luminosities, metallicities and the interstellar reddening to very faint stars at large distances from the Sun. We are planning to investigate the disk population of the Galaxy based on CCD photometry of stars down to 20 mag in about 20 Milky Way areas in the directions where interstellar extinction is low. Additionally, we will investigate molecular and dust clouds in the solar vicinity up to 3-4 kpc distances. Spectral types, luminosity classes, absolute magnitudes, metallicities (for F-G-K stars only), interstellar reddenings, extinctions and distances for all stars down to the limiting magnitude will be determined. These data will be used to get stellar spatial densities of different types of stars, luminosity functions, vertical scale height, radial scale length and thick disk parameters in different directions of the Galactic plane, including spiral arms, interarm regions and the central bulge. This information will be used to verify the existing models of the Galaxy near its plane. No other photometric system, currently in use, can do this type of work. Other aim is to obtain a realistic map of the solar vicinity up to 3-4 kpc showing the positions of molecular and dust clouds, OB-associations and other star-forming regions, open clusters and other tracers of spiral arms.

Estimated observing time needed 2007-2011:
About 10 nights each year
Optimum CNO telescope(s) for your research:
INT WFC with the 34x34 arcmin field
Instrumentation needed or desirable:
The filter set should include the uvby filters of the Strömgren system and PXZS filters of the Vilnius system
Scheduling, observatory services needed:
Any special constraints:

NORDIC OPTICAL TELESCOPE

Strategy Meeting, Nov. 8-10, 2006

Title of Research Group/Project:

Research project: “Late-type stars: Activity, magnetism and turbulence”. Present observing programmes: “Magnetic field polarity in active late-type stars” and “Surface differential rotation of magnetically active single stars”

Science field: Stellar astrophysics

Affiliation:

Observatory, University of Helsinki

Contact person:

Ilkka Tuominen, e-mail: Ilkka.Tuominen@helsinki.fi
Thomas Hackman, e-mail: Thomas.Hackman@Helsinki.fi

Outline of Research Plan for CNO and NOT:

The magnetic activity of $\sim$ 10 late-type stars is studied in terms of Doppler imaging. For 4 stars, we presently use spectropolarimetry for magnetic imaging. The scientific work is a continuation of observations started in 1992.

With these long-term observations we calculate temperature and magnetic field maps, which are used to study variations in the magnetic activity as well as differential rotation of the stars.

Already our results show the occurrences of e.g. flip-flops in several stars, i.e. $\sim$ 180 degrees shifts in the active longitudes. Furthermore we have preliminary estimates of the differential rotation of two stars. We are especially interested in the possible occurrence of magnetic parity shifts connected to the flip-flops.

The ultimate goal is a better understanding of the dynamos of active late-type stars. The observations also form a unique time series comparable to solar spot observations.

Estimated observing time needed 2007-2011:

8-9 nights per observation period.

Optimum CNO telescope(s) for your research:

The observations can be carried out at NOT. A bigger telescope, e.g. TNG would reduce the exposure times, but it is unlikely that such long observation runs that are needed, would be granted.

Instrumentation needed or desirable:

A high resolution spectrograph is needed. The resolution must be R=30000 – 170000 depending on the target. The relevant spectral regions range from 5250 – 7520 Å. Spectropolarimetry is also needed. SOFIN is very well adapted to this work. In the future some observations could also be done with FIES or SARG/TNG.

Scheduling, observatory services needed:

The observations should be spread over at least 10 consecutive shared nights with other high resolution spectroscopy observation projects. The SOFIN observations can be done in service mode with support from the SOFIN team.

Any special constraints:

NORDIC OPTICAL TELESCOPE

Strategy Meeting, Nov. 8-10, 2006

Title of Research Group/Project: HIGH-RESOLUTION SPECTRAL ANALYSIS OF STELLAR ATMOSPHERES

Science field: Stellar astrophysics

Affiliation:
Institute of Theoretical Physics and Astronomy of Vilnius University

Contact person: Grazina Tautvaisiene (taut@itpa.lt)

Outline of Research Plan for CNO and NOT: High-resolution spectral analysis of stellar atmospheres we plan to do for several reasons:

1) investigations of mixing processes in evolving stars (dependence from stellar mass, age, temperature, metallicity, magnetic activity, rotation);

2) determination of the main atmospheric parameters and the detailed chemical composition in stars of open clusters and Galaxtic field in order to investigate the chemical evolution of the Galaxy.

Estimated observing time needed 2007-2011: About 6 - 8 nights per year.

Optimum CNO telescope(s) for your research: Nordic Optical Telescope and Telescopio Nazionale Galileo

Instrumentation needed or desirable:

NOT: SOFIN and FIES;

TNG: SARG.

Scheduling, observatory services needed: No strict requirements for sheduling, service observations or assistance needed.

Any special constraints:

NORDIC OPTICAL TELESCOPE

Strategy Meeting, Nov. 8-10, 2006

Title of Research Group/Project: Asteroseismology with FIES

Science field: Stellar astrophysics

Affiliation: Dept. of Physics and Astronomy, Aarhus

Contact person: Søren Frandsen, srf@phys.au.dk

Outline of Research Plan for CNO and NOT: In connection with the NASA space mission *Kepler* as well as other satellites aimed at planet/asteroseismology targets we plan to observe a range of stellar targets. The measurements will primarily consist in time series measurements of Doppler velocities over observing periods ranging from one week to a month. The dataset need not be continuous for all targets. We will be using FIES/-SARG/"HARPS(ING)" depending on the precision needed for individual targets. In some cases we only want a time series, which permits the large (and small?) separation to be determined. This is in cases, where we want better stellar parameters than one can obtain from photometry/spectroscopy. In other situations we want to participate in coordinated campaigns, where detailed power spectra are needed. This represents an extension of our observations from the southern hemisphere from Chile and Australia.

A related programme on eclipsing binaries will run in parallel. Here we need velocities with a precision $0.1 < V < 1$ km/s. We hope to find a few cases of eclipsing binaries, where we can combine the observations of EBs with seismic measurements.

Estimated observing time needed 2007-2011: 20 nights per year

Optimum CNO telescope(s) for your research: Telescopes with $D > 1m$ and stable, efficient spectrographs with a resolution $R > 40000$

Instrumentation needed or desirable: See above

Scheduling, observatory services needed: There will be different cases. Short ($\leq$ 7 nights) observing runs, a few campaigns ($\leq$ 14 nights) and, if possible, service observations, where a short exposure every hour is needed for an extended period. The relative proportion of the different observing strategies is difficult to predict.

Any special constraints: The potential of FIES in this programme has yet to be explored, and it may be necessary to add an Iodine cell or make some modifications. Sorting this out is part of the science verification programme that begins in January 2007.

NORDIC OPTICAL TELESCOPE

Strategy Meeting, Nov. 8-10, 2006

Title of Research Group/Project:

Science field: Stellar astrophysics

Affiliation: Stockholm Observatory

Contact person: Göran Olofsson (olofsson@astro.su.se)

Outline of Research Plan for CNO and NOT:

As a part of a large project, including far-IR/submm observations with Herschel Space Observatory, and aiming at a better understanding of stellar disk evolution, we propose two types of observations using NOT. First we like to reveal the scattered optical light from disks so far only detected (but not resolved) in the far-IR. Very few disk (presently nine) have been detected in the optical, most of them using HST, and there is a clear need for expanding this sample. The reason why the optical detection is important is the spatial resolution which allows the detection of e.g. voids (signalling the presence of a planet), spirals etc. By combing careful coronography with polarimetry and "lucky astronomy" we believe that our new instrument PolCor on the NOT has the potential for increasing the number of resolved disks.

Obviously, disks and planets around nearby stars offer the best opportunity for more detailed studies (like the Darwin project in the future), but there is one drawback (compared to cluster members): their ages are poorly known. The age is obviously a fundamental parameter in understanding disk evolution (and later in selecting proper targets for searching biospheres). There is, however, one possibility to relatively accurately determine the age of a star: by means of "seismology", i.e. by analysing the vibrational properties of a star deduced from accurate radial velocity monitoring. Typically a week per star is required. NOT + FIES seems to be a perfect tool for this task. So, as a joint project with the Aarhus group, we propose observations of some 30 (TBD) nearby stars, using FIES.

Estimated observing time needed 2007-2011: 40 weeks

Optimum CNO telescope(s) for your research:
Seismology: NOT + FIES
Polarimetric coronography: NOT or WHT (Cassegrain)

Instrumentation needed or desirable:
Seismology: FIES or similar
Coronography: PolCor

Scheduling, observatory services needed:
Seismology: stable weather conditions for a week (moon OK)
Coronography: no moon, good seeing

Any special constraints:

NORDIC OPTICAL TELESCOPE

Strategy Meeting, Nov. 8-10, 2006

Title of Research Group/Project: Asteroseismology of DAVs

Science field: Stellar astrophysics

Affiliation: Institute of Theoretical Physics and Astronomy of Vilnius University

Contact person: Erika Pakstiene, erika@itpa.lt

Outline of Research Plan for CNO and NOT:
I have observed PG 2303+243 (one of cool ZZ Ceti stars) and analyzed its pulsation spectra. Cool ZZ Ceti stars have rich spectra of pulsations with high amplitudes, what change even during one night. It makes ZZ Ceti stars interesting objects for investigation of its pulsation modes and stellar modeling. The cool ZZ Ceti stars are chosen because definition of red edge of ZZ Ceti instability strip is much poorer than of blue edge. My plan for future is to follow up more candidates of cool ZZ Ceti stars to define characteristics of red edge of DAVs.

Estimated observing time needed 2007-2011: 5-7 full nights every 1 or 1/2 year

Optimum CNO telescope(s) for your research: NOT, because I have observed with NOT and I know, that it is equipped with ALFOSC, CCD camera, software and interface, what is needed for my observations. Weather conditions for observations are very good and the size of telescope allows us to get high enough ratio of signal to noise.

Instrumentation needed or desirable: ALFOSC, CCD camera to get time series of observations with short readout time (1-3 s), UBVRI light filters and wide red-cut-off filter, what was used for WET observations.

Scheduling, observatory services needed: 5-7 full nights every 1 or 1/2 year mostly in autumn and/or spring.

Any special constraints:

NORDIC OPTICAL TELESCOPE

Strategy Meeting, Nov. 8-10, 2006

Title of Research Group/Project: Asteroseismology of compact objects

Science field: Stellar astrophysics

Affiliation: Institute of Theoretical Astrophysics, University of Oslo

Contact person: J-E. Solheim, j.e.solheim@astro.uio.no

Outline of Research Plan for CNO and NOT:

Investigantion of light- and spectral variations of compact objects i.e. white dwarfs and subdwarfs, and relate those variations to the spherical quantum numbers k, l, m to model their internal structure. Determination of mass, temperature, thickness of layers of various elements, convection parameters etc. may be achieved for a number of stars. This wil give a possibility to check stellar evolutionary models. Some stars have stable pulsations which may be followed in time to detect periodic changes, which may be due to faint companions as Brown Dwarfs or planets in addition to secular changes due to internal cooling by electromagnetic radiation, neutrino radiation or contraction.

Estimated observing time needed 2007-2011:

4-8 weeks per year.

Optimum CNO telescope(s) for your research:

For continuous photometry:
1. WHT - to reach fainter objects
2. NOT - for bright and medium faint objects

For time resolved spectroscopy:
1: WHT to reach fainter objects
2. TNG do.
3. NOT for medium faint objects

Instrumentation needed or desirable:

For continuous photometry
1. ULTRACAM for fast readout and multi colour simultaneous observations
2. ALFOSC in multi-window mode for continuous photometry

For time resolved spectroscopy:
1: ISIS spectrograph for fast readout medium resolution
2: DOLORES spectrograph for fast readout and medium resolution
3. ALFOSC spectrograph for windowed readout medium resolution

Scheduling, observatory services needed:

For continuous photometry, multi-site observations (around the globe) may be organised
Online reduction programmes (as for ALFOSC windowed photometry mode) is preferred

Any special constraints:

Since resolution in the temporal specta is proportional with time, long observing runs are preferred.

Polarimetric Studies of Interacting Binaries and Magnetic WDs

Science field: Stellar astrophysics

Affiliation: Tuorla observatory

Contact person: Vilppu Piirola (piirola@utu.fi)

Outline of Research Plan for CNO and NOT:

Our aim is to develop and improve the physical and geometrical models for highly magnetic (B=5-200 MG) interacting binaries, their magnetic fields and cyclotron emission regions. There has been remarkable success in explaining the general features of polarization and light curves with existing physical cyclotron models, as applied with numerical geometric models for the emission region(s) on the spinning white dwarf, and for the overall magnetic field structure. However, much remains to be done to improve the models adopted, and the detailed fits to the multicolour ($UBVRI$) and spectropolarimetric data with inhomogeneous and/or multiple emission regions. If cyclotron harmonics are detected in the circular polarization spectrum, strong constraints can be put on multiple pole magnetic field systems. Accordingly, our observations and modelling work will be helpful in developing more realistic physical and geometrical models for the objects, their magnetic fields, and cyclotron emission regions. This will also give new insights into possible evolutionary connections between different types of magnetic CVs.

Among magnetic white dwarfs there is a small group of low temperature helium-rich objects with strong molecular bands of C2 and CH in their spectrum. These bands show a net of circular polarization, which is known as the 'molecular magnetic circular dichroism'. In collaboration with S. Berdyugina and A. Berdyugin, we plan to use these polarized molecular bands as a diagnostic tool for studying magnetic fields on the surface of the cool magnetic white dwarfs, as already successfully demonstrated by our first observations at the NOT (2004) and ESO-VLT(2005).

Estimated observing time needed 2007-2011: 8-10 nights/year, split to 2-3 runs

Optimum CNO telescope(s) for your research:

The good image quality of the NOT makes it a competitive telescope in the 2.5-4 m class, together with the proper instrumentation available for the planned research, and flexibility of the scheduling. For faint objects and/or particular instrument selection, WHT (and Grantecan) will offer interesting alternatives, particularly in the IR wavelength region.

Instrumentation needed or desirable:

For intermediate resolution spectropolarimetry (both circular and linear) and imaging polarimetry, we have found ALFOSC/FAPOL a very efficient and versatile instrument. Also the needs for broad-band continuum polarimetry will be largely fulfilled by ALFOSC/FAPOL. For bright and rapidly variable targets, TURPOL still offers some unique possibilities with high S/N and time resolution in simultaneous multicolour ($UBVRI$) C&L polarimetry and photometry. Our recent work with TURPOL includes also massive interacting binaries which are in a stage of very intense mass transfer (see Piirola et al., 2005, ApJ, 632, 576; Piirola et al., 2006, A&A, 454, 277). Possibilities to continue such programmes at the NOT would be desirable.

Scheduling, observatory services needed:

For the relatively short period (typically 1h$< P <$8h), but highly time-variable, targets, optimal length of observing runs is normally 2-4 nights, to obtain good S/N and to follow the night-to-night variability. Since the unpredictable behaviour of targets may require fine-tuning of the observations during the run, *visitor* mode is often desirable. However, *beat* periods of WD spin and the orbital period in asynchronous systems may require special scheduling arrangements, with shorter observing blocks distributed over several weeks or months.

Any special constraints:

NORDIC OPTICAL TELESCOPE

Strategy Meeting, Nov. 8-10, 2006

Title of Research Group/Project:
Variability of Interacting binaries (Lehto, Hakala, Katajainen)

Science field: Stellar astrophysics

Affiliation: Tuorla Observatory, University of Turku

Contact person: Harry Lehto, hlehto@utu.fi

Outline of Research Plan for CNO and NOT:
We have the following main lines of research.
1) Photometric, polarimetric and spectroscopic studies of the nature of individual interacting binaries. Present theories of interacting binaries are not able to address several questions in their observed properties, e.g. the value of the real minimum orbital period of CVs or the evolutionary path of non-magnetic CVs and magnetic CVs and their relations to other types of interacting binaries.
2) Optical photometry and spectroscopy to study thick accretion disks in interacting binaries (LMXB, SSS, Nova-likes). The aim is to derive constraints on the accretion disc shape and structure and compare those with the disc theories/simulations.
3) To investigate the nature of interacting binaries by wide field imaging photometry. These will provide us with new types of CVs, with unbiased measures of space densities and with measures of ages of interacting binaries, which is an important, but poorly known parameter in CV evolutionary models. We will also search (and follow up) new short period binary systems in the frame work of the RATS survey.

Outline of Educational Activity:
Data is suitable for training PhD students. Provided funding is available 4 Ph.D. students could be trained with this data.

Estimated observing time needed 2007-2011: 53 nights in total.

Optimum CNO telescope(s) for your research:
NOT ALFOSC/TURPOL: The only possibility for a publicly available instrument capable of fast circular and linear photopolarimetry.
WHT ISIS: spectropolarimetry
WHT ULTRACAM: Not a common user instrument. This visiting instrument is capable of very fast photometry
INT: Wide field imaging
TNG+WHT: Spectroscopy of wide field follow up observations.

Instrumentation needed or desirable:
1) ULTRACAM as a regular instrument (any telescope)
2) Capability for a set of full polarisation instruments, and in particular one capable of *fast (∼ms) simultaneous linear and circular photometry* and also one capable of *time resolved circular and linear spectropolarimetry.*
3) Wider field and faster readout CCD for INT

Scheduling, observatory services needed: Some observations will be time critical - need to be in blocks of at least of one orbital period (1-12 hours, depending on the target)

Any special constraints: –

NORDIC OPTICAL TELESCOPE

Strategy Meeting, Nov. 8-10, 2006

Title of Research Group/Project:
Planetary-System Research Group / Nordic NEON

Science field:
Solar System studies

Affiliation:
University of Helsinki

Contact person:
Karri Muinonen, karri.muinonen@helsinki.fi

Outline of Research Plan for CNO and NOT:
For several years now, our research group has been involved in near-Earth-asteroid studies with several other Nordic institutions. We have used the name Nordic NEON (Near-Earth-Object Network) for our collaboration. We have carried out both photometric lightcurve observations and astrometric observations with the NOT. Out of the photometry, we have derived spin-axis orientations and shape estimates for several asteroids. Astrometry has produced improved orbital parameters for a lot of potentially hazardous objects (PHOs) and other near-Earth objects (NEOs) of interest and we have also recovered some lost asteroids. As a side result, we have also discovered a new main-belt asteroid.

In the future, we plan to continue our observation program and include polarimetric observations of NEOs. Polarimetric observations from three or more phase angles allow the assessment of the geometric albedo of the asteroid and thus its tentative taxonomical classification. Polarimetry as a tool in planetary astronomy is undergoing a renaissance. Our group is the leading group in the world in the theoretical understanding and interpretation of the polarization of light scattered from, e.g., asteroid surfaces.

Instead of the successful monthly service-mode astrometric observations, we are planning to utilize the new fast-track service-mode opportunity to observe PHOs at times when new critical observations are needed.

The foundation of CNO would suit our research well. Our group has already in the past collaborated with other European NEO researchers. The prospect of doing so under the CNO umbrella looks very promising. For example, we could envision joint programs in photometry and polarimetry with A. Cellino from Osservatorio Astronomico di Torino and in astrometry with A. Boattini from Spaceguard Central Node. Such programs could use both the NOT and the TNG.

Estimated observing time needed 2007-2011:
6-9 nights per period

Optimum CNO telescope(s) for your research:
Because of the observational flexibility of our research, no single telescope is optimal. Instead of pointing out optimum telescope(s), we give an explanation on what we could do with the three suitable CNO telescopes for our research.

- NOT: With the NOT, our vision is to keep on doing photometric and astrometric observations and also to begin polarimetric observations. The NOT is an excellent telescope for all of those observations because of its (and ALFOSC's) versatility and ease of use. The ability to do imaging and polarimetry easily with the same instrument (ALFOSC/FAPOL) is of great value. Also our familiarity with the NOT is a great asset.

- INT: The Isaac Newton Telescope offers new possibilities in astrometry because of the $\sim 0.5^\circ \times 0.5^\circ$ FoV of the WFC. Photometric observations are also possible.

- TNG: TNG, having a larger mirror, offers enhanced possibilities for astrometry and photometry. With larger mirror we can observe both smaller new objects and observe the targets already observed with the NOT at greater distances thus providing greater phase-angle coverage.

Instrumentation needed or desirable:
Visible wavelength CCD camera with Bessell BVR filters (ALFOSC, WFC, OIG,...). For polarimetry, FAPOL or similar CCD-based polarimeter.

Scheduling, observatory services needed:

We would need several 2-3 night runs per period to obtain optimum science gain. This is because we need to obtain data in at least three different phase angles per target. The targets are on orbits that allow them to be observed only for a few months per apparition (in which time the phase angle changes considerably). In principle, we are quite flexible with the specific times for those runs. It's sufficient that they are placed within a week-and-a-half of the requested time.

We don't anticipate the continuity of astrometric or any other regular service mode observations in the near future. Instead we are considering the possibility to use the "fast-track" service observing mode for some critical targets.

Any special constraints:

As mentioned in the previous item, obtaining enough data on the targets with different phase-angles is crucial to the scientific outcome of the observations. This means that we have to put some constraints on when the observations are made during the observing period. However this is not very rigid. Also, the nature of our research dictates that we need to have some continuity in the observations throughout the observing periods to be able to gather enough data on the individual targets (can take a few years according to the orbits). On the technical side, the telescope needs to be able to differentially track objects that can move several arcseconds per minute.

NORDIC OPTICAL TELESCOPE

Strategy Meeting, Nov. 8-10, 2006

Title of Research Group/Project:
Instrument Center for Danish Astrophysics (IDA)

Science field:

Affiliation:
Danish astrophysics

Contact person:

Jens Hjorth (ida@astro.ku.dk)

Outline of Research Plan for CNO and NOT:

IDA's mission in this context is to support competitive astrophysics research conducted at Danish research institutions. IDA is interested in optimizing science return and quality from Danish involvement in large international facilities, including the NOT/CNO.

There is no research plan as such, but IDA gives priority to projects within the focus areas defined by the Danish 'Astronomisk Udvalg': cosmology and galaxy formation, star and planet formation, and extreme astrophysics.

IDA sees the NOT/CNO play an important role for preparing/supplementing observations with large ground-based facilities (e.g., VLT, ALMA) and space observatories (e.g., HST, JWST).

In making decisions about the future of NOT/CNO IDA recommends

- a bottom-up vs. a top-down process where all interested scientific astrophysics groups and individuals with credible and realistic ideas and plans are heard.
- that scientific strength and potential must be the guiding (if not overruling) principle, even if this would imply diminished access for large fractions of the community.
- that scientific impact of projects and instruments be gauged from a bibliographic analysis of publications based on NOT over the past decade.

As inspiration for the future operations of the NOT, IDA points to possible parallels with the experience in transforming the operations of the Danish 1.5m telescope at La Silla. Previously, of order 5–10 nights per project were granted to visiting observers. IDA brought together groups of scientists sharing overlapping interests and subsequently encouraged large observing programs, typically of one-month durations. For the Danish 1.5m, this process resulted in a few large consortia and fewer PIs and CoPIs. Remarkably, despite diminished support and maintenance of the telescope, this boosted the scientific output and allowed for a more efficient use of guest observers. It must be stressed that such a process does not happen automatically and would have to be initiated and encouraged by NOT if a similar strategy were to be adopted at the NOT/CNO.

Estimated observing time needed 2007-2011:

Optimum CNO telescope(s) for your research:

Instrumentation needed or desirable:

Scheduling, observatory services needed:

Any special constraints:

NORDIC OPTICAL TELESCOPE

Strategy Meeting, Nov. 8-10, 2006

Nordic-Baltic Research Schools in Lithuania:

Science field: Stellar astrophysics

Affiliation: Institute of Theoretical Physics and Astronomy, Vilnius University, Lit

Contact person: Grazina Tautvaisiene (taut@itpa.lt) - local organiser

Jan-Erik Solheim (j.e.solheim@astro.uio.no) - scientific organiser

Hans Kjeldsen (hans@phys.au.dk) - scientific organiser

Outline of Educational Activity: Nordic-Baltic Research school in Aug 2008 and maybe Aug 2011

Estimated observing time needed 2007-2011: 2.5 nights in Aug 2008, maybe the same in 2011

Optimum CNO telescope(s) for your research: NOT for remote observing

Instrumentation needed or desirable: 2008: FIES or ALFOSC, later unknown

Scheduling, observatory services needed: August is the best time, Remote observations necessary

Any special constraints: Assistance from local staff