KOSMOS System Design Note 1.03

Title: **ReSTAR Science Requirements for KOSMOS**
Author: **Knut Olsen**
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Introduction

Low and medium resolution optical spectroscopy is a basic tool that is critically important for a broad range of astronomical research. Measurement of stellar radial velocities and galaxy redshifts, object classification, confirmation of photometrically identified candidates, and determination of physical properties such as temperature and metallicity all depend on obtaining optical spectra. Low and medium spectroscopy on NOAO's 4-m telescopes remains in demand, and will likely increase as future survey facilities, such as LSST, PanSTARRS, and GAIA, come into service. Mid-sized telescopes will continue to be very valuable for their ability to acquire spectra in the V~15-21 magnitude range, allowing the larger telescopes to be reserved for the faintest targets. As the ReSTAR committee noted, the continued demand for spectroscopy on mid-sized telescopes provides strong motivation for delivering modern spectroscopic capabilities on NOAO's 4-m telescopes. The proposed KOSMOS spectrograph represents a substantial upgrade over the current 4-m R-C spectrograph, as the completely transmissive design has significantly higher throughput, allowing it to reach fainter magnitudes in the same exposure time. With multi-object slit masks available over a several arcmin field of view, it will also be a capable instrument for survey follow-up, as it should have comparable A-Ω to the GMOS spectrographs on Gemini. These features make OSMOS an excellent match to many of the science cases outlined in the ReSTAR report.

Spectral Requirements for KOSMOS for specific ReSTAR science cases

Low-resolution spectroscopy

The ReSTAR science cases requiring low-resolution spectroscopy are the studies of Kuiper Belt objects and asteroids in the solar system. Asteroid spectra contain broad reflectance features that are used to classify them according to their composition. The typical resolution requirements are R~200 over wavelengths $\sim 0.4<\lambda<1$ μm (e.g. Moskovitz et al. 2008). For KBOs, the typical features seen in optical spectra are CH4 and O2 ice absorption bands at wavelengths of $\sim 0.5<\lambda<0.95$ μm, which have widths in excess of 20 nm. The resolution requirement is R~200 – 400, in order to have 10 – 20 resolution elements across these bands (e.g. Licandro et al. 2006, Alvarez-Candal et al. 2008).

The ReSTAR document mentions the need for high-resolution spectroscopy to support the study of asteroids in the solar system; no papers in the literature support this need.

Medium-resolution spectroscopy (R~1600–2250)

The majority of ReSTAR optical spectroscopic science cases require medium spectral resolution. Examples cases are:

- Stellar spectral classification for measurements of the IMF requires R~2250 spectroscopy in the blue, 390<λ<500 nm (e.g. Massey et al. 1995). The need is to resolve particular absorption lines that are sensitive to temperature and luminosity.
- The confirmation and characterization of brown dwarfs requires R~2000 spectroscopy in the red, 0.6<λ<1 μm (e.g. Burgasser et al. 2009).
- Spectroscopy for confirmation and characterization of novae requires R~2000 with a wavelength range of ~450<l<700 nm. The requirement is based on the need to identify the typical emission lines present in novae and on the need to resolve velocity widths of the lines down to ~300 km s^{-1} (e.g. Neill & Shara 2005).
- Spectroscopy of AGN has similar requirements to those of observations of novae, but generally extending to longer wavelengths to account for the typically higher redshifts of AGN. For example, the recent discovery of a possible binary supermassive black hole AGN system by Boroson & Lauer (2009) employed R~2000 spectroscopy in the wavelength region ~400<λ<900nm. The spectral resolution allowed measurement of emission line widths down to ~300 km s^{-1}.
- Spectroscopy for galaxy redshifts and absorption line strengths is typically done with R~1500–2000, over wavelengths ~370<λ<950nm (e.g. Brown et al. 2009). The resolution is required for the measurement of spectral indices and to avoid excessive smearing of the bright night sky emission lines present at red wavelengths.
- Galaxy rotation curves can be measured with R~2000 spectroscopy; the ~10 km s^{-1} delivered velocity accuracy is sufficient for rotation curves galaxies as small as massive dwarf galaxies.
- Studies of extragalactic globular cluster systems are generally done with R~2000 spectroscopy over wavelengths 370<l<600nm, where the requirements are for measurement of integrated age and metallicity-sensitive spectral indices, and velocities good to ~10 km s^{-1} (e.g. Olsen et al. 2004).

Cases requiring R~3000 or higher resolution

A few ReSTAR optical spectroscopy science cases require higher resolution:

- Measurement of the Ca triplet in giant stars in Local Group galaxies requires R>2800 at 850nm (e.g. Cole et al. 2004). This resolution is needed to separate the individual lines in the triplet. The Ca triplet is a particularly useful metallicity indicator for Local Group galaxies.
- Stellar kinematics with ~5 km s^{-1} accuracy is well-served with R~3000 spectroscopy. Such velocity accuracy is needed for the study of kinematics in many dwarf galaxies, which have rotation curve velocities <50 km s^{-1}.

- For red spectroscopy, R~3000 avoids blending of the bright night sky emission lines, which can be important for spectroscopy of faint targets in the red, such as extragalactic supernovae.
- Radial velocity curves in eclipsing binary systems become possible to do at R~4500 for massive binary systems. Low-mass (~1 M_{sun}) eclipsing binary systems require R~20000–40000 for <1 km s^{-1} velocity accuracy (e.g. Meibom et al. 2009).

Versions

Version	**Date**	**Changes**
1	10/2/2009	First draft