NIFS
GEMINI

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ATMOSPHERIC REFRACTION EFFECTS IN NIFS

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Revision History

Revision No.	Author & Date	Approval & Date	Description
Revision 1	Ian Price 27 October 1999		Original document.
Revision 2	Peter J. McGregor 12 April 2000	Jan van Harmelen 12 April 2000	Reformatted for Word 2000. Updated following CoDR.

Contents

1 Purpose

The purpose of this document is to describe effects due to differential atmospheric refraction that will be relevant to the design and operation of the Gemini Near-infrared Integral-Field Spectrograph (NIFS).

2 Applicable Documents

Document ID	Source	Title
SDN0005.21	RSAA	NIFS Grating Selection
GNIRS SDN0019	NOAO	Differential Refraction

3 Introduction

The Gemini Near-infrared Integral-Field Spectrograph (NIFS) will have a 3.0″×3.0″ field-of-view and use 0.1″ wide slitlets to perform near-diffraction-limited imaging spectroscopy at near-infrared wavelengths. Performing imaging spectroscopy at high spatial resolution requires consideration of the effects of differential atmospheric refraction on the resulting data. Atmospheric refraction shifts the apparent positions of objects by an amount dependent on the zenith distance of the object and the wavelength of observation. Differential atmospheric refraction will affect NIFS in two ways; light at one end of a recorded spectrum will originate from a slightly different position on the sky to light at the other end of the spectrum, and the apparent separation and orientation between a science object and its On-Instrument Wavefront Sensor (OIWFS) guide star will vary with time during long observations.

Similar considerations apply to both NIFS and GNIRS. The analysis presented here follows the analysis of differential atmospheric refraction effects in GNIRS (GNIRS SDN0019, Differential Refraction).

4 Differential Atmospheric Refraction Model

The refractive index of air at temperature T = 15°C, pressure P = 760 mm Hg, and at a vacuum wavelength of l_{vac} (mm) is given by

$$n-1=10^{-8}\left(6431.8+\frac{2949810}{146-s^{2}}+\frac{25540}{41-s^{2}}\right)$$

where $s = l_{vac}^{-1}$ (Edlén 1953). The refractive index is adjusted for temperatures and pressures appropriate to Mauna Kea (T = 0°C and P = 452 mm Hg) using the expression

$$n_{T,p}-1=(n-1)\frac{1.549.P\left(1+P(1.049-0.015.T)10^{-6}\right)}{760.4696(1+0.0366.T)}\approx 0.92(n-1)$$

(Barrell & Sears 1939). The Earth's atmosphere can be modeled as a flat slab of air with uniform thickness and refractive index $n_{T,P}$. Atmospheric refraction causes an angular displacement, z, of the apparent zenith angle of an object, z_{app}, from its true zenith angle, z_{true}, which is given by

$$z=\left(z_{true}-z_{app}\right)\approx\left(n_{T,P}-1\right)\tan z_{true}\,.$$

The differential refraction between two closely spaced objects is then obtained by differentiation such that

$$dz\approx\left(n_{T,P}-1\right)\sec^{2}z_{true}dz\approx 2.7\times10^{-4}\sec^{2}z_{true}dz$$

where dz is the true zenith angle difference between the two objects and the constant is applicable over the wavelength range 0.9-2.5 mm.

4.1 Implications for Guiding

NIFS will use the OIWFS to offset guide the science object with OIWFS guide stars located up to 60″ from the science object (with ALTAIR). The OIWFS will normally be operated in the same wavelength range as the science observation by appropriate selection of the OIWFS filter. As was found for GNIRS, differential refraction between the science object and the OIWFS guide star can then amount to ~ 0.066″ (~ 1.6 pixels) over 4 hr integrations in which the zenith distance changes by ~ 60°. This offset will be corrected by the Telescope Control System (TCS) offsetting the OIWFS X-Y gimbal position during the exposure. A wavelength-dependent offset will have to be applied if the OIWFS is not operated at the same wavelength as the science instrument.

4.2 Implications for Science Observations

Differential refraction also causes the image of an object to appear at different positions in the telescope focal plane depending on the wavelength of observation. If the NIFS IFU slitlets are aligned parallel to the vertical direction, the red and blue ends of an object spectrum will appear at different spatial positions in the slitlet. These displacements are shown as functions of zenith angle for the NIFS gratings (NIFS Grating Selection, SDN0005.21) in Figure 1 to Figure 4. The effect is significant above a zenith angle of ~ 60° for the *J1* and *J2* gratings. The ALTAIR atmospheric dispersion corrector should be used for observations with these gratings.

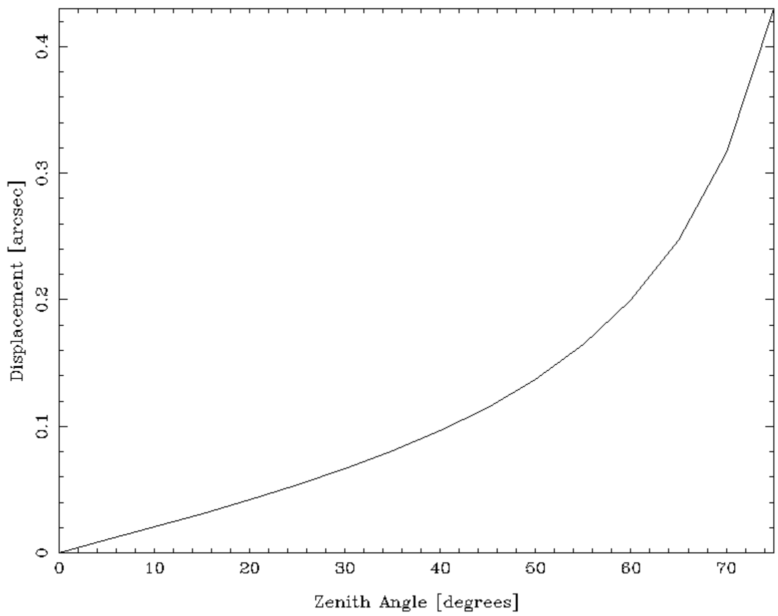

Figure 1: Differental atmospheric refraction between extreme wavelengths recorded with the *J1* grating.

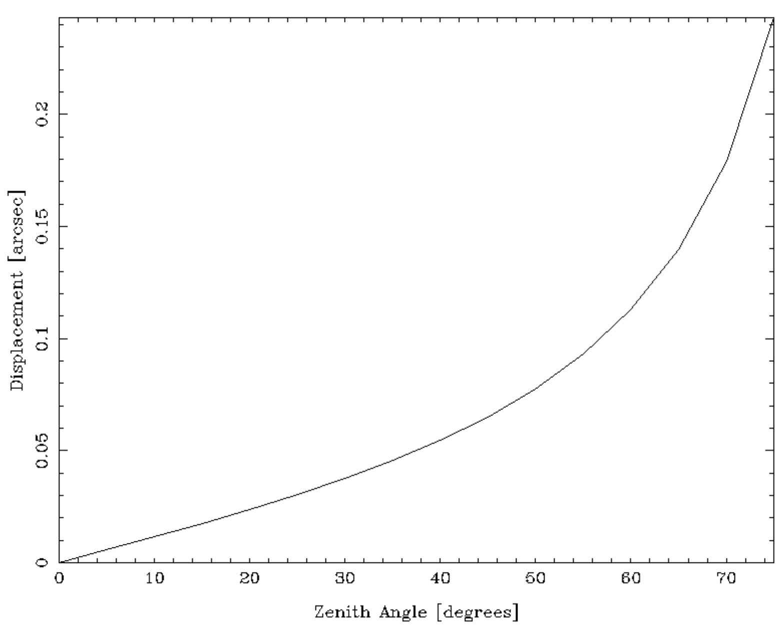

Figure 2: Differental atmospheric refraction between extreme wavelengths recorded with the *J2* grating.

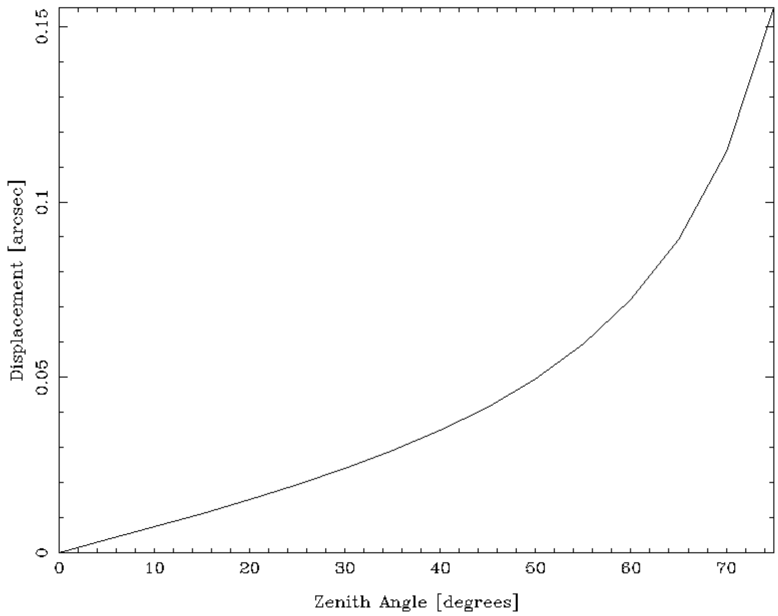

Figure 3: Differental atmospheric refraction between extreme wavelengths recorded with the *H* grating.

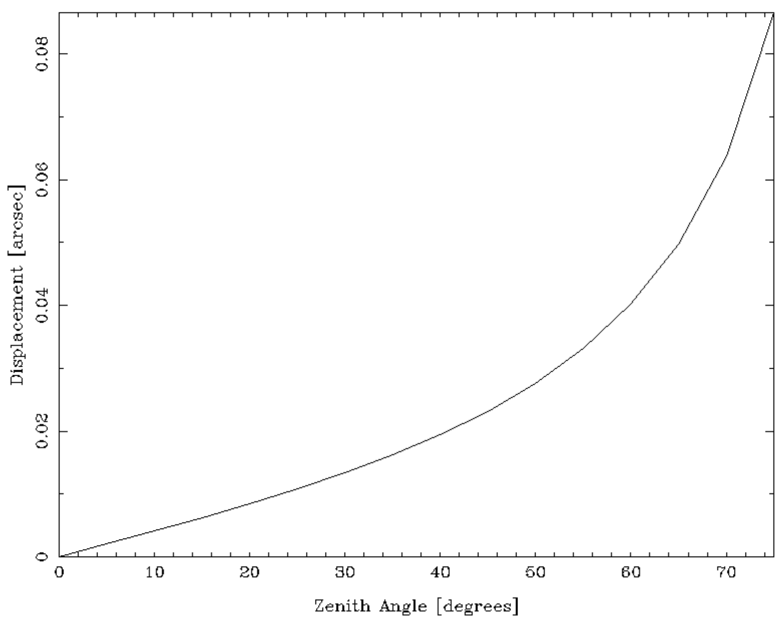

Figure 4: Differental atmospheric refraction between extreme wavelengths recorded with the *K* grating.

5 References

Barrell, H., & Sears, J. E. 1939, Trans. Roy. Soc. (London) A238, I
Edlén, B. 1953, JOSA, 43, 339

Appendix A: List of Figures

Figure 1	ref_j1.gif
Figure 2	ref_j2.gif
Figure 3	ref_h.gif
Figure 4	ref_k.gif