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PRAXIS: an OH suppression optimised near infrared spectrograph

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ABSTRACT

The problem of atmospheric emission from OH molecules is a long standing problem for near-infrared astronomy. We are now close to solving this problem for the first time with the PRAXIS instrument. PRAXIS is a unique spectrograph which is fed by fibres that remove the OH background, and is optimised specifically to benefit from OH-Suppression. The OH suppression is achieved with fibre Bragg gratings, which were tested successfully on the GNOSIS instrument. The OH lines are suppressed by a factor of ~ 1000, leading to a reduction of the integrated background of a factor ≈ 9. A future upgrade to multicore fibre Bragg gratings will further increase this reduction. PRAXIS has had two commissioning runs, with a third commissioning run planned for July 2019, which will be presented at the conference. PRAXIS has a measured throughput of ≈ 20 %, demonstrating high effiency in an OH suppression instrument for the first time. Science verification observations of Seyfert galaxies demonstrate the potential of OH suppression.

Keywords: Near infrared, spectroscopy, OH suppression, astrophotonics, fibre Bragg gratings

1. INTRODUCTION

Near-infrared spectroscopy is significantly hampered by the brightness of the night sky.[1] The night sky surface brightness is orders of magnitude brighter than the objects one wishes to observe, leading to significant Poissonian noise after sky-subtraction. This problem is exacerbated by the temporal and spatial variation of the night sky emission, which varies by a factor ≈ 2 throughout the night, with a further random variation of $\approx 10\%$ on the timescales of minutes. Therefore systematic errors make accurate sky-subtraction even harder.

Between 1 and 1.8 μm this background is dominated by emission from OH radicals in the upper atmosphere. These OH lines are intrinsically very narrow ($< 2 \times 10^{-13}$ m) and very bright. Between the OH lines the sky background has been measured to be very dark, ≈ 300 ph s^{-1} m^{-2} μm^{-1} arcsec^{-2}. Therefore selectively filtering these OH lines would significantly reduce the near-infrared background, and allow much deeper spectroscopy.[1]

A large step towards this goals was made by the GNOSIS instrument[2] which used fibre Bragg gratings to reject the 103 brightest OH doublets, reducing the night sky background by a factor of 9.[3] Despite this success, GNOSIS did not exhibit increased sensitivity over standard NIR spectroscopy. The reason is that the reduction in background from OH suppression was offset by an increase in background from the instrument thermal emission, and an increase in the relative significance of the detector noise, due to lower sky background and lower total throughput. Likewise, previous OH suppression schemes, such as high dispersion masking, or

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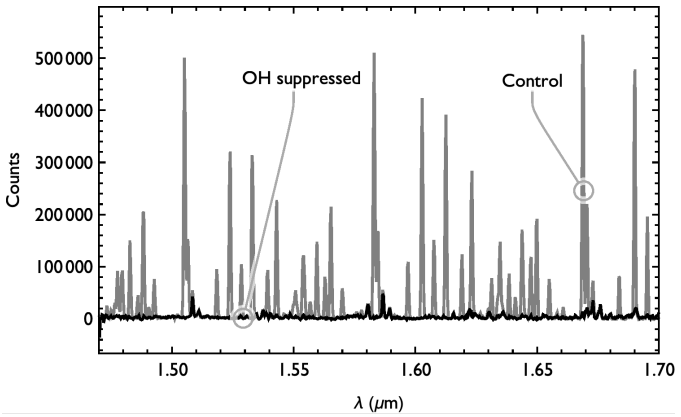
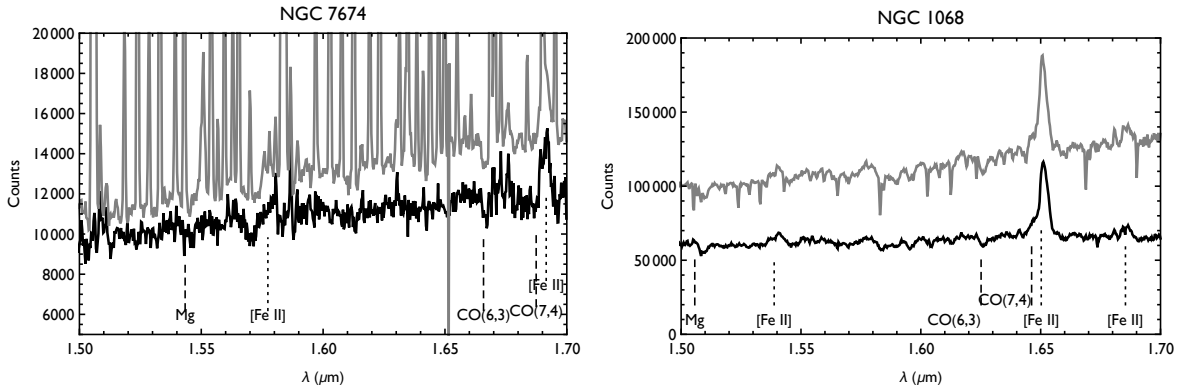


Figure 1. The PRAXIS sky-background, after dark subtraction, with and without OH suppression. The integrated background is reduced by a factor ≈ 8.



(a) NGC 7674 (b) NGC 1068 – 2 arcsec N of nucleus

Figure 2. Examples of OH suppression for two Seyfert galaxies. Long exposures can lead to very large systematic sky-subtraction residuals, such as those very evident in the control fibres (grey lines). With OH suppression, both emission and absorption features are easily observable (black lines), which are otherwise hidden by the sky-subtraction residuals.

holographic gratings, have all suffered from some defect, such as instability and unreliability in the rejection, or inefficiency of the overall system, and prior to PRAXIS no OH suppression scheme has been implemented with high overall efficiency.

PRAXIS has now achieved OH suppression in a high efficiency instrument for the first time. This is an important milestone, since it proves that there are no inherent impediments to photonic OH suppression with fibre Bragg gratings, and that this is possible in an efficient instrument, paving the way for a facility-class OH suppression instrument. PRAXIS has had two commissioning runs so far, with a third run planned for July 2019. We will describe the PRAXIS instrument, and the principles of OH suppression upon which it operates. We will present results from the commissioning tests, showing the reduction in sky background (Figure 1) possible with OH suppression, the instrument throughput, and the increased signal-to-noise in science observations (Figure 2) made possible with this technology.

REFERENCES

[1] Ellis, S. C. and Bland-Hawthorn, J., "The case for OH suppression at near-infrared wavelengths," *MNRAS* **386**, 47 (2008).

[2] Trinh, C. Q. et al., "GNOSIS: The First Instrument to Use Fiber Bragg Gratings for OH Suppression," *AJ* **145**, 51 (2013).

[3] Ellis, S. C., et al., "Suppression of the near-infrared OH night-sky lines with fibre Bragg gratings - first results," *MNRAS* **425**, 1682–1695 (2012).

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