IGRINS-2 SV Observation Evaluation Form

Title: Coronal Line Emission in NGC 6302
Program ID: GN-2024B-SV-110
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Description of the primary goals and the main findings

We observed the extreme bipolar planetary nebula (PN) NGC 6302. This source contains several solar masses of nebular material irradiated by a luminous, extremely hot central star (T > 200,000 K), descended from an intermediate-mass (~5-6 $M_{\odot}$) object. The central star is surrounded by a dense molecular disk, and drives focused, axisymmetric outflows of ionized and molecular material at velocities of up to hundreds of km/s. The goal of these observations is to study the abundances and kinematics of gas near its dense, dusty molecular torus, including coronal lines such as [Al IX] 2.04 μm, [Ca VIII] 2.32 μm, and [Si VI] – [Si IX] lines, taking advantage of the high velocity resolution (~6.7 km/s) of IGRINS-2 in order to examine systematic differences between distinct components projected along the line of sight as well as between neutral and ionized regions.

The IGRINS-2 spectra (Fig 1) reveal a wealth of H I (up to at least n=50), He I, He II, [Fe II], and H2 lines, as well as the very bright coronal lines of [Si VI] 1.96 and [Si VII] 2.48 microns. In addition, the spectra exhibit several lines from neutron-capture (r-process) elements, including [Br V], [Ge VI], [Kr III], [Se IV], and [Te III]. The H2 lines are particularly interesting as they are numerous and exhibit a two-component profile with a deep absorption between the peaks and a velocity separation of about 30 km/s. H2 lines from levels as high as v=12 have been detected, which suggests the lines are excited by fluorescence. This in turn indicates that the density of the emitting gas cannot be very high, as high densities would tend to thermalize the H2 levels. The [Fe II] lines exhibit a profile similar to that of the H2 lines, which indicates that this emission arises from a PDR layer associated with the molecular torus. The 2-d spectra also reveal remarkable velocity variations along the slit (Fig 2.)

We are analyzing the spectra with the aim of determining the density of the H2 emitting gas, the ionization state of the coronal gas, the abundances and enrichments of the neutron capture elements, and the temperature of the central source.

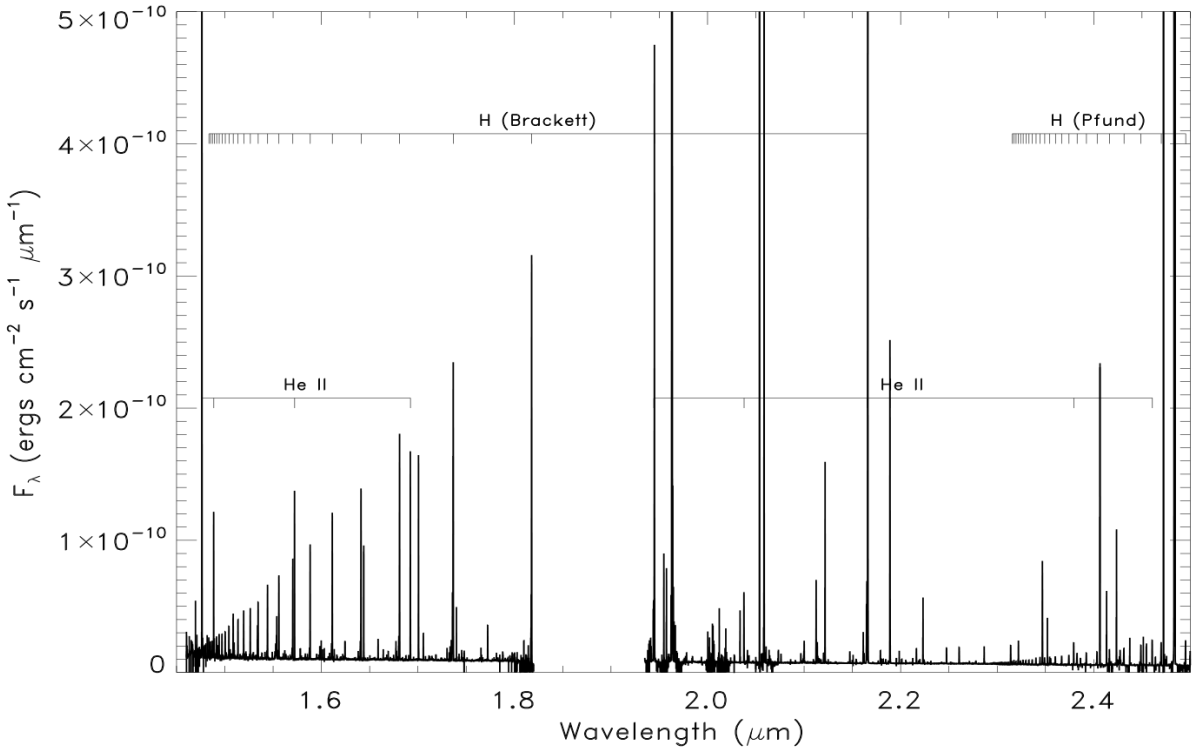

Fig 1. - Telluric-corrected and flux-calibrated IGRINS-2 H and K band spectra of the PN NGC 6302. Numerous strong lines of H I, He I, and He II are present, as well as the coronal lines of [Si VI] and [Si VII] at 1.96 and 2.48 microns, respectively.

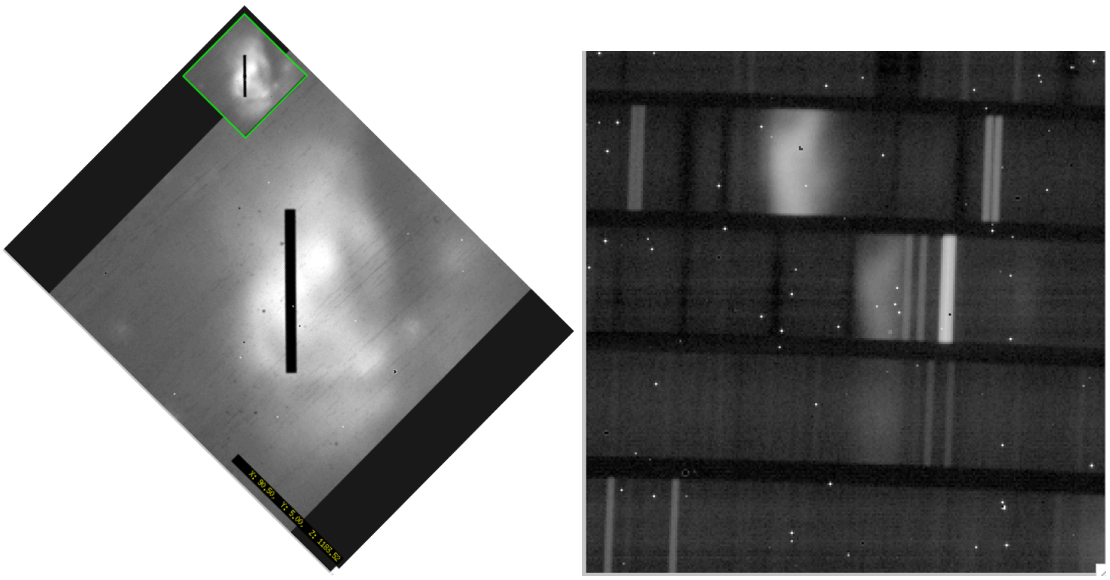

Fig 2. (left) Location of the IGRINS-2 slit. (right) Velocity variation of the bright emission along the slit. (The straight lines in the spectra are telluric emission due to OH.)

Additional comments on IGRINS-2 performance:

Suggestions for improvements:

The pipeline reduction worked reasonably well. However, the telluric correction provided by the pipeline was insufficient for our purposes, as it left a large number of very strong residuals in the spectra which hindered line identifications and measurements. In addition, the pipeline does not generate flux-calibrated spectra. We developed our own telluric correction and flux calibration code to overcome this shortcoming.

Any additional comments about IGRINS-2 SV