NACO Observations of the Galactic Center

Scientific Rationale

High spatial resolution observations of the motions of gas and stars have in the past decade substantially strengthened the evidence that central dark mass concentrations reside in many and perhaps most nuclei of nearby galaxies. These dark mass concentrations are most likely supermassive black holes with masses ranging from 10^6 to $10^{9.5}$ $M_\odot$. The case of the Galactic center is particularly intriguing. With the highest spatial resolution observations achievable with diffraction limited imaging on 10m-class telescopes in the near-infrared ($\sim$50 milli-arcsecs), spatial scales of a few light days can be probed. Measurements of both line-of-sight velocities and sky/proper motions are available for several hundred stars provide compelling evidence for the presence of a central compact mass of 2.4 to 3.3×10^6 $M_\odot$. The location of maximum stellar velocity dispersion, the center of gravitational force, and the position of a compact hard X-ray source seen with Chandra agree to within $\pm$0.1 arcsec with the position of the compact radio source SgrA*.

Recently obtained CONICA-NOAS data have also had a large impact on our understanding of the dynamics and recent and past star-formation of the Galactic Center. These are:

(1) One of the stars, S2, reached peri-center passage over the commissioning period of NACO during which time it reach a velocity greater than 5000 km/s! Since S2 was observed during apo-center at the beginning of the GC monitoring campaign with Sharp on the NTT this full data set has allowed us to fit a highly significant orbit solution. This provides has provided a constraint for the black hole mass of about a factor of 10 better than had previously been obtained. These additional SV observations will allow us to continue tracing the orbit of S2 at a time when it will be significantly distant from the position of SqrA* further constraining its orbital parameters (as well as those of other fast moving stars), and perhaps even more importantly, to begin to look at the faint stars near the central mass of the GC and emission from SqrA* itself.

(2) The previously obtained L-band commissioning data have caused a particular excitment in that there is a possibility that SqrA* (the puntative black hole) is visible in the L-band. Such a detection would put strict limits on the accretion rate of the black hole and have a myriad of implications for how BHs grow, are fueled, and radiate. Unfortunately, the closeness of S2 to the position of SgrA* has heretofore made it impossible to be certain that the observed L-band emission is not from S2. With the rapid motion of S2, it should be possible to distinguish conclusively emission from S2 and emission at the position of SqrA*

(3) The complexity of the absorption along the line-of-sight to the GC hampers the determination of a mass function of stars near the GC. From observations taken with CONICA-NAOS during the commissioning and paranalization/SV

possible peculiarities the mass function of the cluster surrounding the GC. Such a robust determination of the mass function has strong implications for how the star formation proceeded in the GC or how the young stars may have dynamically sank into the center. To determine a robust mass function requires a estimate of the distribution of the extinction to each individual star or group of stars. Comparing the H, K, and L-band images would be an important step in this direction, not to mention making for a really nice color image!

With all of these goals in mind to supplement our already obtained data on the Galactic Center, we have designed a program to take deep images of the GC in H, Ks, and L' bands with NACO during SV.

Observations

We propose deep H-, K_s-, and L-band AO observations of the central $\pm 13''$ centered on SgrA*, using NAOS' infrared wavefront sensor and CONICA at the highest possible spatial resolution of 13.25 mas pixel^{-1} for H- and K_s-bands and 27 mas pixel^{-1} for the L-band. The bright supergiant IRS 7 ($\sim 6.5^m$) in the GC stellar cluster can be used as infrared guiding star (target-source separation $\sim 6''$, see Figure 1) for the H- and K_s-bands. The total integration times are 20 minutes in each of the H- and K_s-bands and one hour in the L-band.

Figure 1: The central $\pm 13''$ around SgrA*. The approximate radio position of SgrA* and of IRS 7 ($m_K \sim 6.5$) are labeled.