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Study of the molecular gas in the central parsec of the Galaxy through regularized 3D spectroscopy

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Abstract. The cool gas in the central parsec of the Galaxy is organized in the surrounding circumnuclear disk, made of neutral gas, and the internal minispiral, composed of dust and ionized gas. In order to study the transition between them we have investigated the presence of H_2 neutral gas in this area, through NIR spectro-imaging data observed with SPIFFI. To preserve the spatial resolution we implemented a new method consisting of a regularized 3D fit. We concentrated on the supposedly fully ionized central cavity and the very inner edge of the CND. H_2 is detected everywhere: at the boundary of the CND and in the central cavity, where it seems to split in two components, one in the background of the minispiral and one inside the Northern arm.

Keywords. central parsec: molecular gas, methods: data analysis, techniques: spectroscopic

1. Introduction

In the central parsec of the Galaxy the cool gas is organized into two major structures: the circumnuclear disk (CND), which is molecular, and the minispiral, mainly atomic and ionized. These are morphologically different but both are of the same clumpy nature and present a spatial coincidence. To understand the origin and dynamics of these structures, in particular the transition between them, we have investigated the presence of molecular gas H_2 in the inner part of the CND, where the ionized Minispiral lies.

2. Observations and data processing

We are provided with NIR spectro-imagery data set taken by SPIFFI, the near-infrared integral field spectrograph on the VLT, already published in Eisenhauer *et al.* (2003). We are grateful to S. Gillessen of the MPE for giving us access to these data. The observed field of view is $36'' \times 29''$ and the spectral resolution $R = 1500$. The spectral range covers, in particular, two H_2 lines (2.122 μm and 2.223 μm) and the Brγ line (2.166 μm). There are other molecular or ionized lines, e.g. FeIII, which will be presented in a further study. The analysis consists in creating maps of three physical parameters: line intensity, radial velocity and width. Usually the approach is to fit the spectrum of each spatial pixel, but, if the signal-to-noise is not good enough, the risk is to fit a wrong spectral feature because of a noise spike. Instead, we implemented a new method which consists in a regularized three-dimensional fit, for further information see Paumard *et al.*, these proceedings. Stars could locally bias results, due to increased photon noise and spectral features near the H_2 lines; our regularized fit provides for interpolation over these regions.

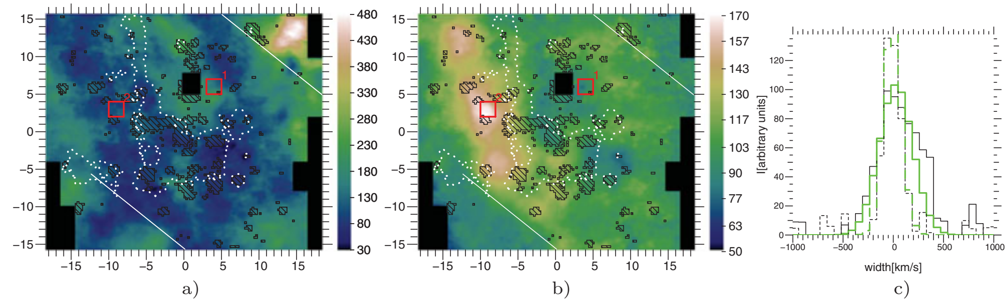

Figure 1. H_2 line **a)** intensity (arbitrary units) and **b)** velocity (km s^{-1}) maps. These images are centered on Sgr A* and displayed in arc-seconds. The meshes indicate the interpolated areas. The dotted line traces the contours of the Brγ emission and the solid lines delimit the CND emission. The two squared frames correspond to spectra shown in **c)**, where data (dark lines) are displayed with model (light lines) for zone 1 (solid line) and 2 (dashed line). [A COLOR VERSION IS AVAILABLE ONLINE.]

3. Preliminary Results

We obtained the regularized line flux and line velocity maps shown in Figure 1; the velocity map is not reported because it doesn't add any further relevant information, because of insufficient signal-to-noise. We are confident the obtained results are reliable despite the difficulty to estimate error bars with this method, since we have checked on several individual spectra that the model accurately reproduces data. In particular width variations are significant.

The H_2 intensity map shows that the molecular gas is detected everywhere. In the South-East and North-West corners there are respectively a weak and a strong emission most probably dominated by CND molecular gas which is located there. This interpretation agrees with the known inclination of the CND (Liszt 2003) showing a stronger emission for the closer side. It is interesting to notice that the H_2 emission remains fairly strong into the inner cavity, close to the center, where it should be more unlikely for the molecular gas to resist dissociation. The shape of the Minispiral seems to stand out where the emission values are lower, in particular there is a well defined boundary West of the vertical Brγ emission.

The H_2 width map presents some bright features (i.e. large width) slightly shifted (East) with respect to the Northern arm boundary of the Minispiral. This arm is in fact a thick cloud (Jackson *et al.* 1993), whose Eastern boundary is traced by the vertical Brγ emission. The width map features correspond, in projection, to this clump suggesting that the H_2 emission could come from inside this cloud, protected by an ionization front. Even though this interpretation is tempting, this structure is morphologically visible only on the width map. As for the intensity map the emission seems to come from the background of the Minispiral and the extinction due to its dust could be hiding the H_2 structures. Our interpretation is that we are observing three distinct H_2 components: one associated with the CND, one in the background (intense and narrow line) and one into the Northern arm (less intense and wide). To confirm this interpretation we will investigate the apparent anti-correlation between the intensity and width maps, derive uncertainties and compare with other species.

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