VLT / KMOS view of the explosive outflow in Orion BN/KL

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Abstract

Orion BN/KL hosts a unique outflow containing more than 100 individual jets resembling those of young stellar objects. The directions of the jets strongly suggest an explosive origin linked to the decay of a non-hierarchical system of massive stars (Youngblood et al. [5]). Here, we present near-IR (1.4-2.4 μm) spectral maps of these "Orion fingers" using the K-band Multi Object Spectrograph (KMOS) at VLT. The H_2 and [FeII] lines are used to determine gas physical conditions and dynamics. The observations reveal the properties of shocks in this unique region with good spatial and spectral resolution at the same time.

Orion BN/KL outflow

The Orion BN/KL region hosts a 500 years old explosive outflow located in the OMC1 at 414 ± 7 pc[4]. It is famous for its wide-angle hydrogen structures that look like fingers and bullets discovered by Allen & Burton [1]. The origin of this very strong emission is supposed to be a single, dramatic event, e.g. a close interaction and disruption of a massive young stellar system [6]. The outflow is well-known and widely studied using observations in IR, submilimeter and radio regime. Radio and submilimeter observations suggest that hot core inside the region could be heated by a group of stars at a distance of 0.1 pc or by fast energetic shocks and that most of the IR sources are not self-luminous. The OH massers in the region are moving with velocity 10 times larger than that in typical interstellar matter. The hottest molecular material emit energy up to 943 K, while the temperature of the Orion's hot core is about 200 K (Zapata et al. [7]). There is an absence of remarkable class II methanol maser typical for such „hot cores".

Observations

Observations were made using the K-band Multi Object Spectrograph (KMOS) on VLT in 2015. KMOS is an unique instrument allowing to observe many objects simultaneously and perform Integral Field Spectroscopy. It uses 24 configurable arms with field of view 2.8×2.8 arcsec each. Full instrument with the field of view of 7.2 arcmin in diameter. It observes in near-IR (IZ, YJ, H, K and HK bands) with spectral resolution of ∼4000 [3]. Our observations were made in HK band with R∼1800 in Mosaic mode using all 24 arms. Field of view for that configuration is 64.9×43.3 arcsec.

Conclusions

We detect 11 bright H_2 emission lines, Paschen α and Brackett γ line tracing „fingers" features. 1-0 S(1) line is 2-8 times stronger than other hydrogen lines. [Fe II] lines are the strongest at the tips of the jets. Maximum brightness of 1.6440 μm [Fe II] emission is ∼4 times weaker than maximum H_2 emission at 2.1218 μm. The velocities are greater than 30 km/s. CO-overtone band is not detectable.

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Background: image from [2]: 2.1218 μm H_2 in red, 1.644 μm [Fe II] in green and K_S image in blue.

Results

We found 11 H_2, Paα, Brγ and 3 [Fe II] emission lines. H2 lines reveal the structure of the outflows in the region. Ferrum emission traces the tips of the jets - the „fingertips". The brightnest line is H_2 1-0 S(1) line at 2.1218 μm. We obtained radial velocities derived from Gaussian fits of hydrogen and iron lines. Radial velocities obtained using H_2 and [FeII] lines are ∼50 km/s.

Brightness and velosity maps

Line emission and velocity maps obtained at 2.1218, 2.2235, 1.6440 μm lines (corresponding transitions: H_2 1-0 S(1), 1-0 S(0) and [Fe II] 4F-6D).

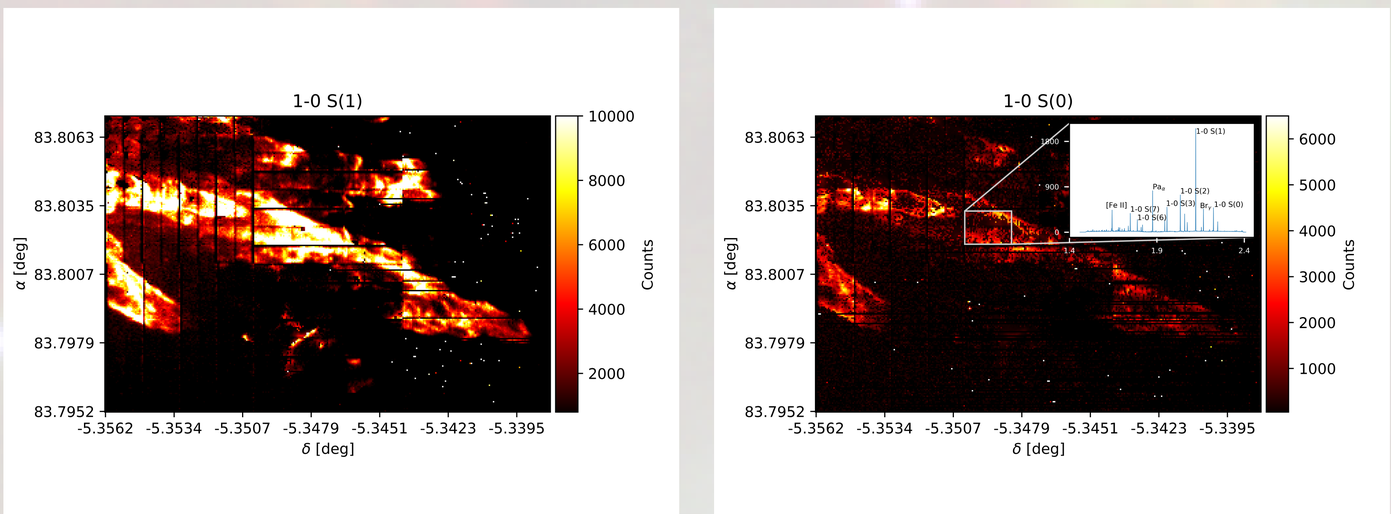

Figure 1: Line emission maps in H_2 2.1218 (left) and H_2 2.2235 μm lines (right). On the corner there is shown average spectrum from marked region with several lines.

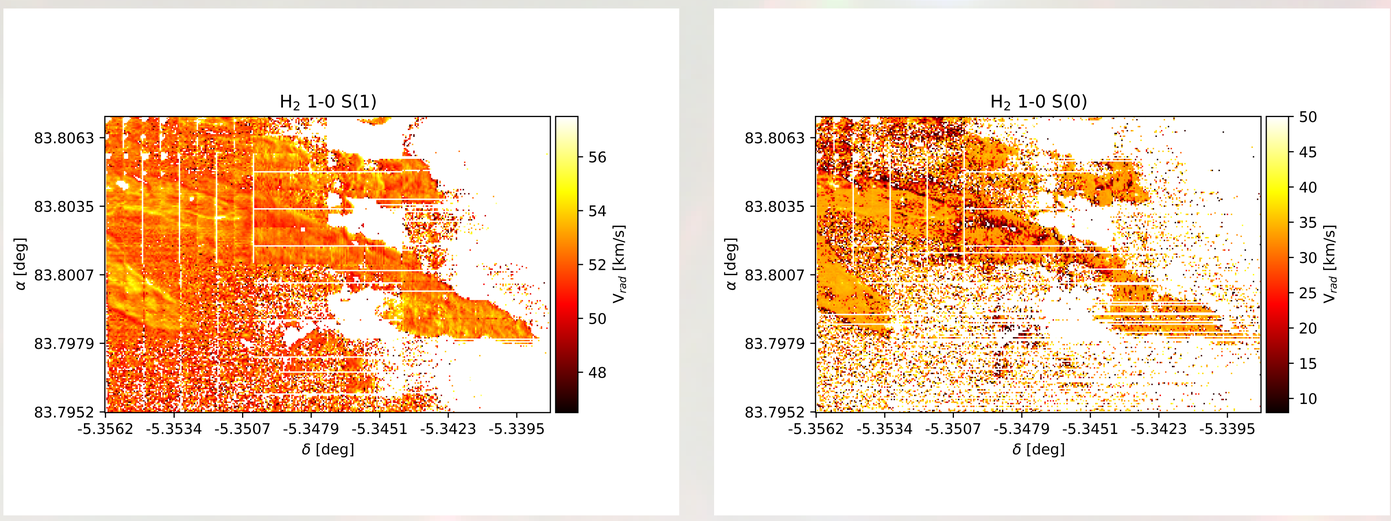

Figure 2: Velocity maps in H_2 2.1218 μm (left) and H_2 2.2235 μm (right).

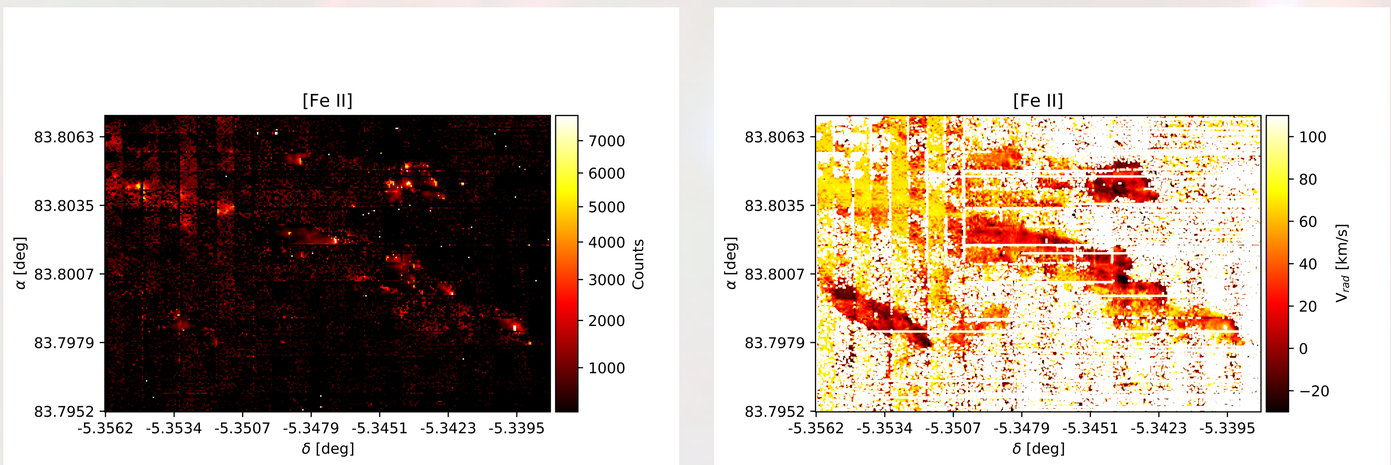

Figure 3: Line emission map (left) and velocity map (right) in [Fe II] 1.6440 μm line.

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