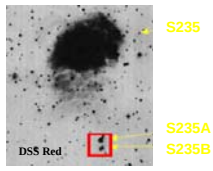
H_α observations of the outflows in S235A-B region with Fabry-Perot interferometer at 6-m telescope of SAO RAS

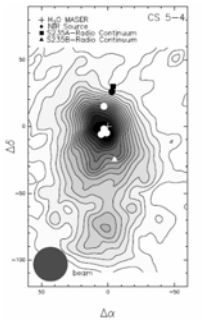
Sobolev A.M.[1], Moiseev A.V. [2], Krushinsky V.V.[1], Vasyunina T.S.[3]

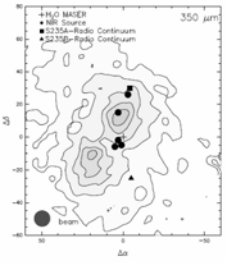
[1] Ural State University, Ekaterinburg, Russia; [2]Special Astrophysical Observatory of Russian Academy of Sciences, Nizhny Arkhyz, Russia; [3]Max-Planck-Institut fur Astronomie, Heidelberg, Germany



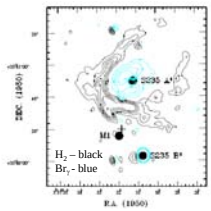
General information on S235A-B region of star formation

S235A-B is the site of active star formation located to the south of the bright optical HII region S235 (see Fig.1). The site contains 2 developed optical HII regions, S235A and S235B, and very young star cluster embedded in the hot and dense molecular core. Notations of the HII regions were suggested by Glushkov et al. (1975) who attracted attention to the fact that H_a spectrum of the southern HII region S235B displays unusually high velocity dispersion. Later the region was extensively observed in the radio and infrared ranges. This delineated the edges of the molecular core located between S235A and S235B and revealed presence of the numerous young stellar objects and molecular outflow (see, e.g., Lee et al. 2002, Felli et al. 1997, 2004, 2006 and poster by Kirsanova et al.). Here we show the first results on the kinematics of the objects in the region based on observations of H_a.





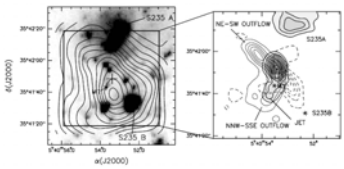
Molecular and dust emission from Lee et al. (2002)



Molecular and ionized hydrogen emission from Felli et al. (1997)

K colour image, HCN emission and water maser

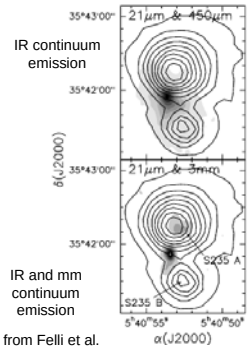
HCO+ outflow and 3.3 mm continuum emission



Molecular line emission and emission in radio and IR continuum from Felli et al. (2006)

IR continuum emission

IR and mm continuum emission



Images of S235A-B in H_α and infrared

H_a image obtained at 6-m telescope in 2007 displays bright HII regions, S235A and S235B, surrounded by diffuse emission and 3 compact sources.

S235A: It is clearly seen that the S235A object consists of 2 parts containing stars of similar brightness both in optics and IR. Radiocontinuum images display similar morphology. This suggests that this HII region is born by 2 stars which have created a cavity surrounded by the common H_2–dust envelope.

S235B: With respect to S235A this nebula has smaller size and similar brightness in H_a and optical continuum. At the same time the star which excites S235B is considerably brighter than both exciting stars of S235A. This says that this region is probably younger.

Compact sources comp1, comp2, comp3: Images discover compact sources showing pronounced emission in H_a, optical and IR continuum.

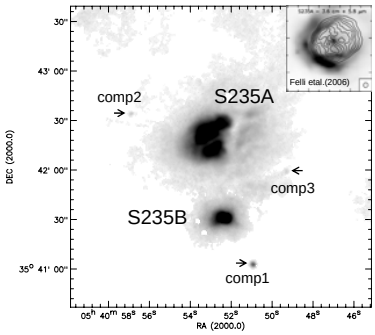


Image in H_a line emission

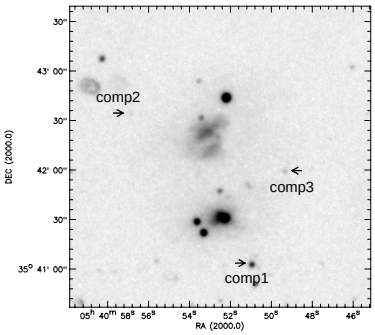
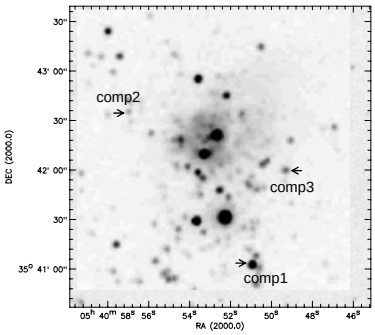
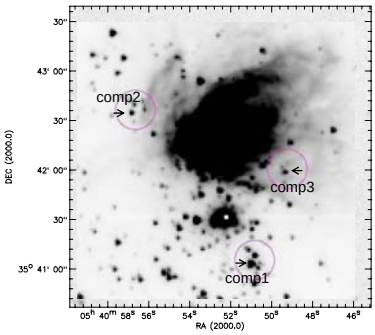


Image in continuum at H_a wavelength



2MASS image in K_s colour



Spitzer image at 3.6 μm

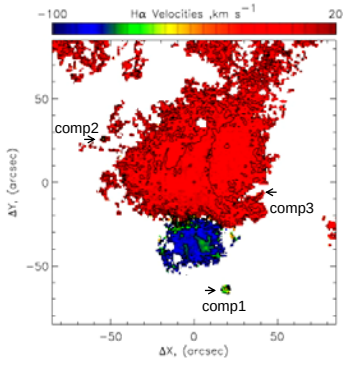
Kinematics of the gas in the objects of S235A-B region revealed by H_α emission

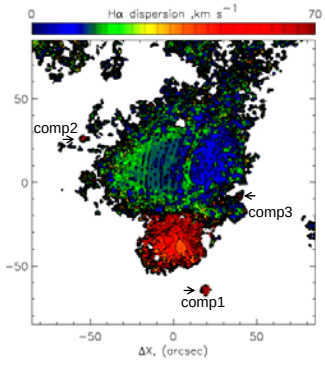
Fabri-Perot interferometer at 6-m telescope of SAO RAS allowed to obtain H_a images with velocity separation of ~33.5 km/s. Maps in individual velocity channels and the maps of H_a velocity and velocity dispersion are given below.

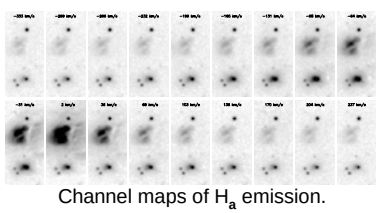
S235A: Velocity of this HII region is close to that of molecular gas. Both velocity and velocity dispersion of H_a line do not display detectable gradients.

S235B: Ionized gas of this nebula departs toward us from its parent molecular cloud with velocity exceeding 50 km/s. Velocity dispersion exceeds 30 km/s and is the highest in the surrounding diffuse emission. It reaches its maximum of ~70 km/s at the position of the molecular outflow seen in HCO^+(1-0) line.

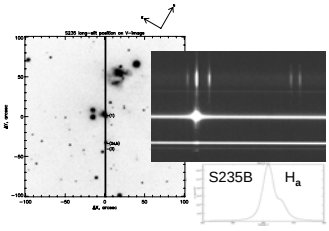
Compact sources comp1, comp2, comp3: H_a velocity dispersion in all of these objects exceeds 30 km/s. Velocities of comp2 and comp3 are likely to be more negative than the systemic one but additional integration is needed. The gas of comp1 is departing toward us with velocity exceeding 50 km/s. IRAC colours of this object show that it is surrounded by considerable amount of the gas probably residing in the circumstellar disk.







Channel maps of H_a emission.



Slit position in the V colour image and the spectra around H_a.

Slit spectra at H_α wavelengths obtained with 6-m telescope

Spectrum of S235A corresponds to the normal HII region. Spectra of S235B and comp1 show stellar continuum and broad H_a line without emission in the other nebular lines. A weak nebulosity emitting in H_a is detected to the SW of comp1.

General conclusions

Kinematics of the objects in S235A-B region is studied using optical line observations with 6-m telescope of SAO RAS. Images and spectral properties of S235A correspond to the evolved HII region created by 2 stars with similar luminousity. H_α velocity dispersion in the region between S235A and S235B which harbours molecular outflow is greatly enhanced. S235B shows high H_α velocity dispersion and its emitting in H_α gas is departing from the parent cloud toward us with velocity exceeding 50 km/s. 3 compact objects with the broad H_α emission are discovered. Most probably the S235B and compact objects are strongly accreting stars.