

The 3D velocity and magnetic fields of a MHD disk-wind (DW) around a forming star

L. Moscadelli¹, A. Oliva², A. Sanna³, G. Surcis³, M.T. Beltrán¹, R. Kuiper⁴

In October 2020 Global VLBI observations of the 22 GHz water masers towards the YSO ($5.6 \pm 2.0 M_{\text{sun}}$) IRAS 21078+5211 (Fig.1) have found that the water masers trace sinusoids on the plane of the sky (Fig.2), which can be interpreted in terms of 3D motions along the helical magnetic field lines of a MHD DW (Fig.3). Our simulations reproduce both the maser kinematics (Fig.4) and the 3D magnetic field from maser polarization (Fig.5).

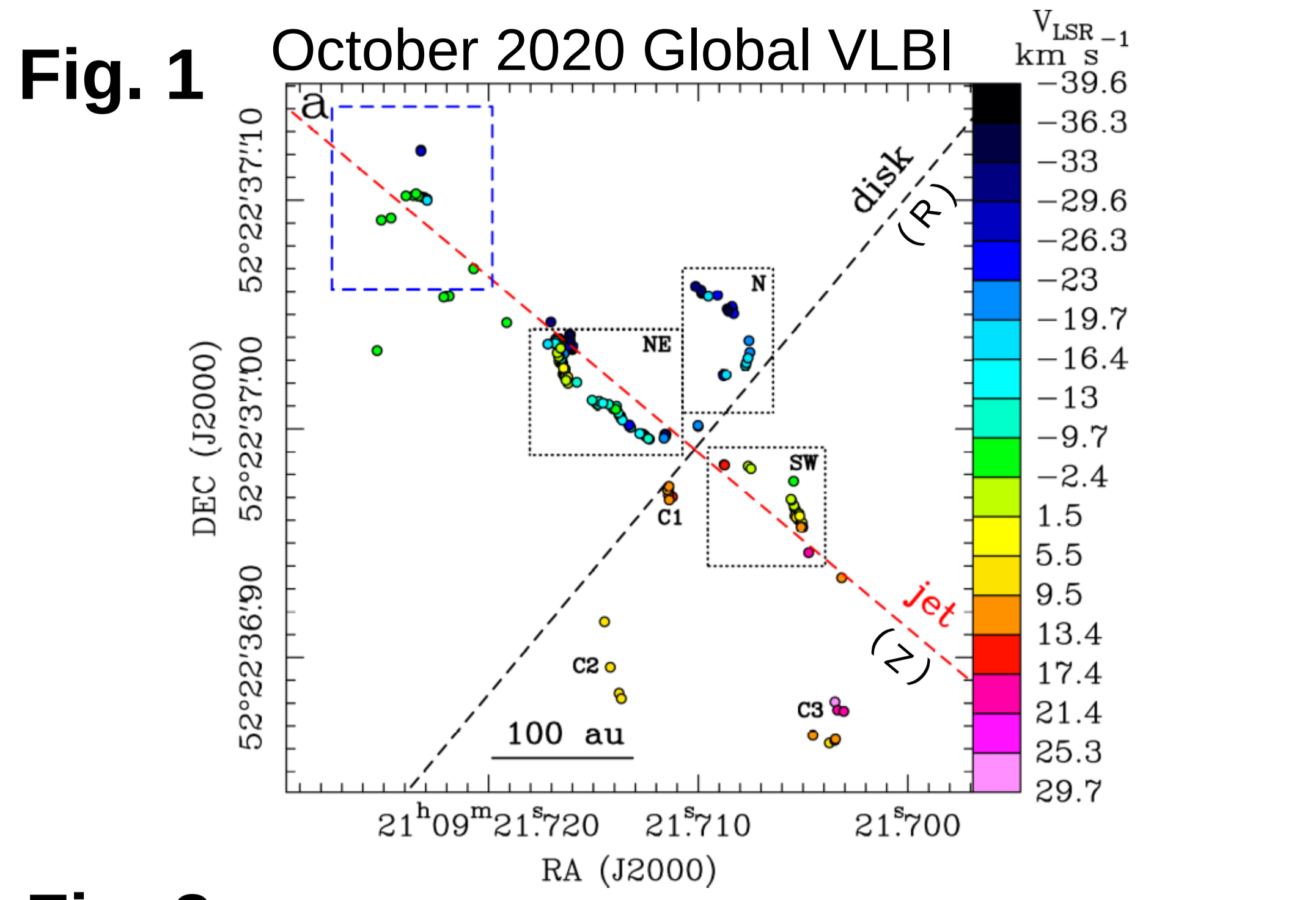


Fig. 1

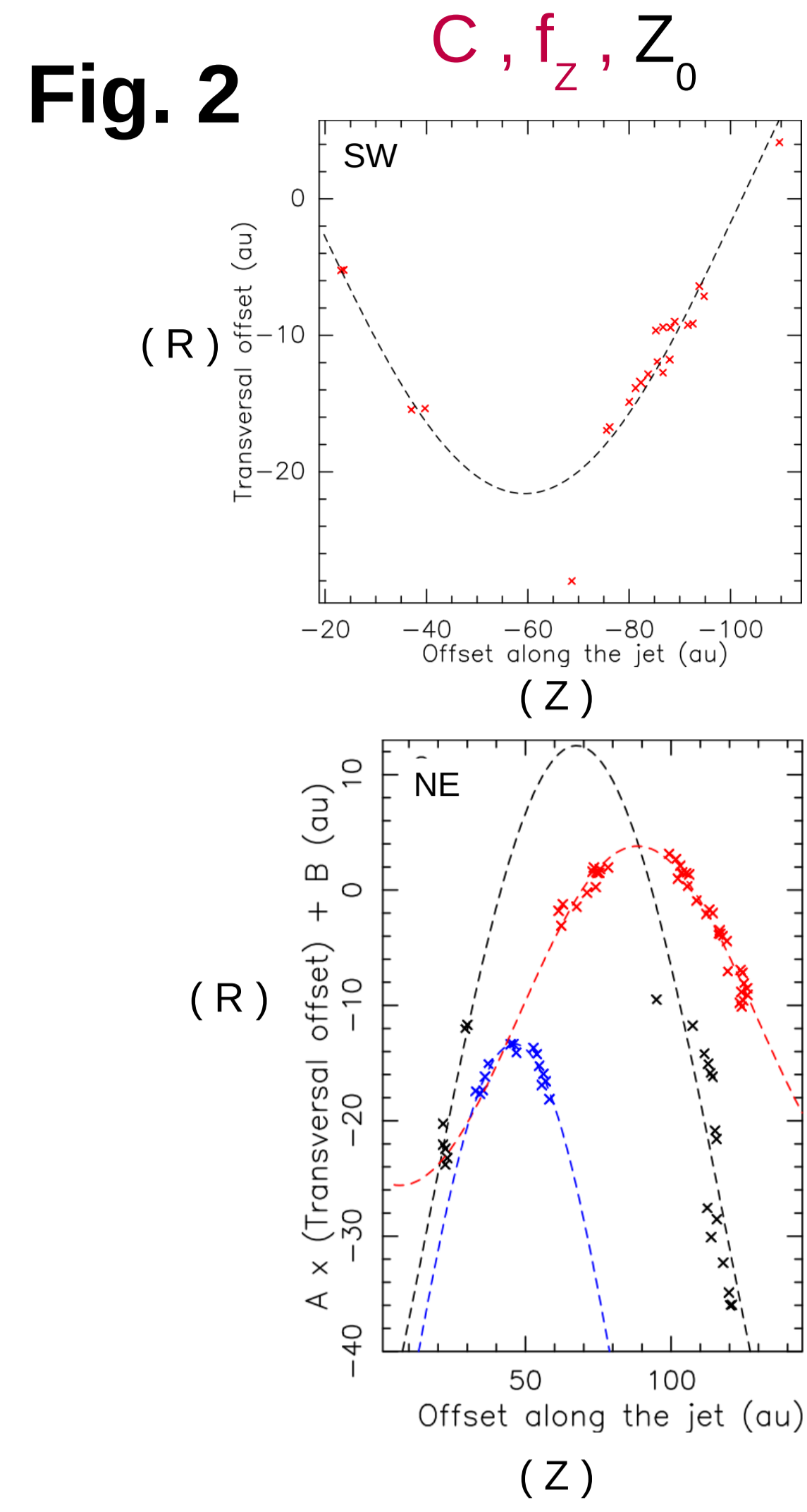


Fig. 2

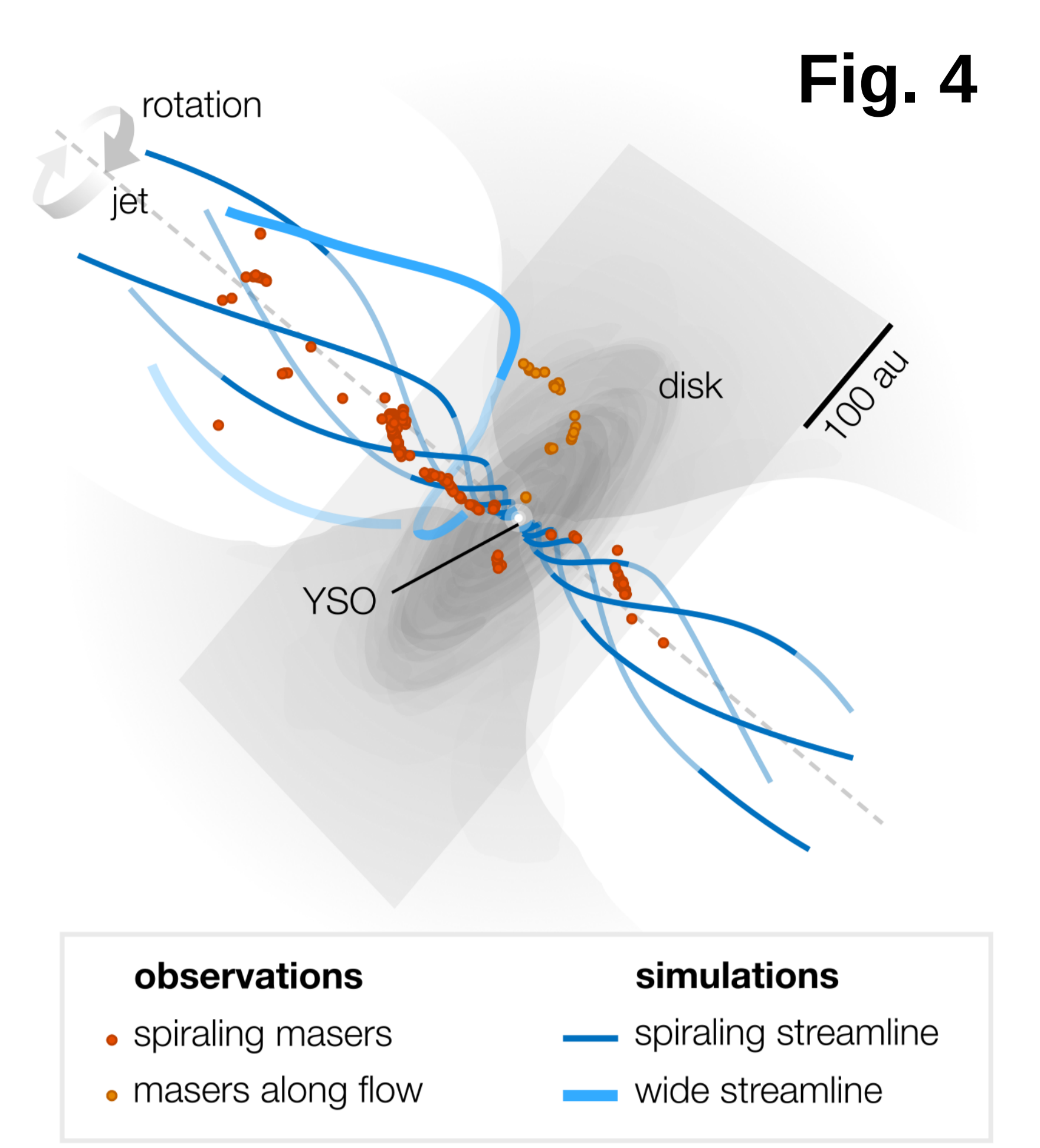


Fig. 4

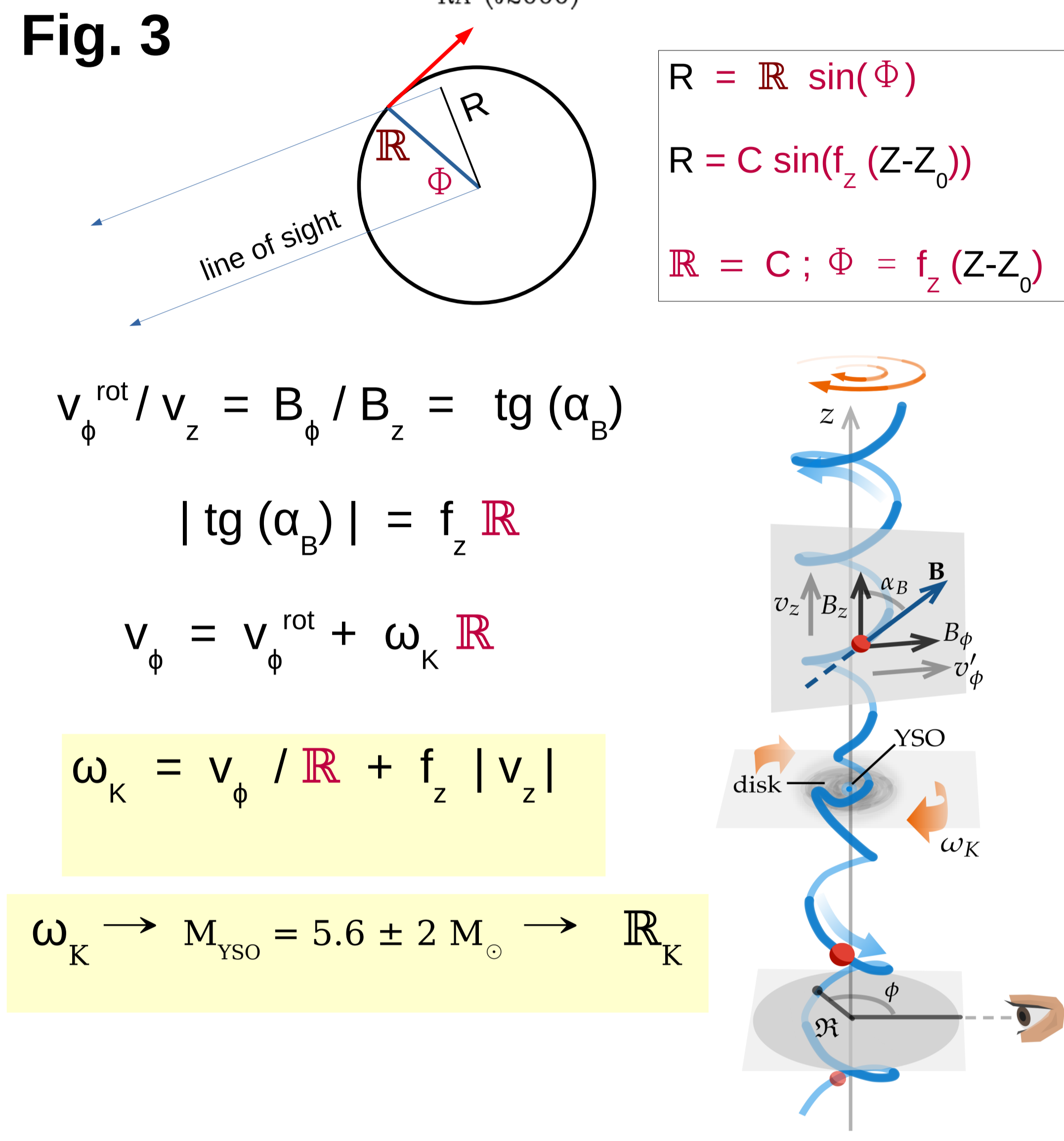


Fig. 3

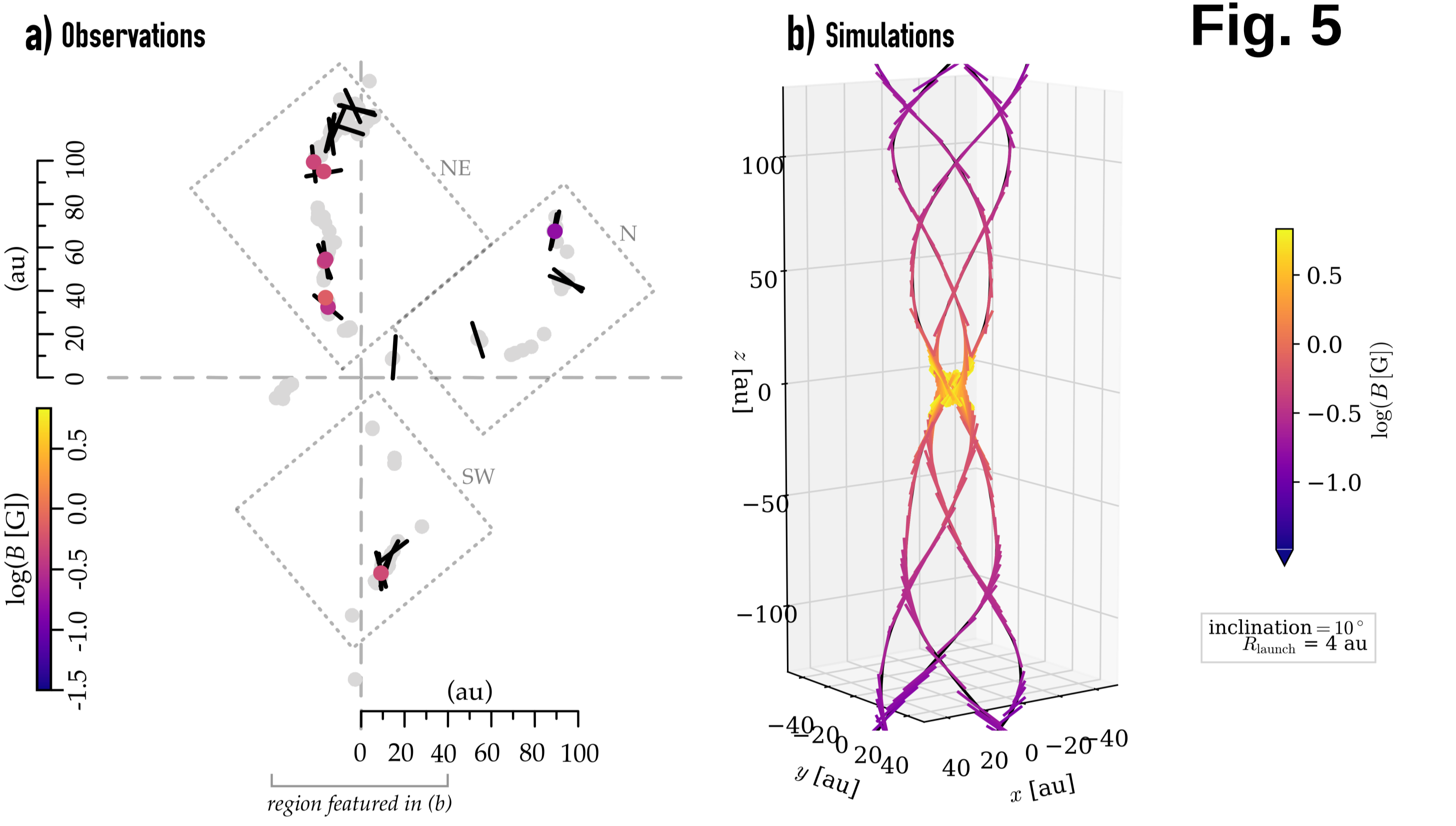


Fig. 5

In March-October 2023 we re-observed the water masers in IRAS21078+5211 with VLBA at four epochs to measure the proper motions (Fig.6a). The water masers are concentrated in the same regions of the previous (October 2020) observations, to the NE, SW and N of the YSO, but they trace different streamlines: B1 and B2 in the NE (Fig.6b), and R1 in the SW (Fig.6c) region. The masers belonging to the same streamline yield consistent values for the angular velocity of the launch radius (Fig.7a), which is a direct test of the adopted model of a MHD DW. The launch radii are determined with accuracies of ~ 1 au (Fig.7b and Table1).

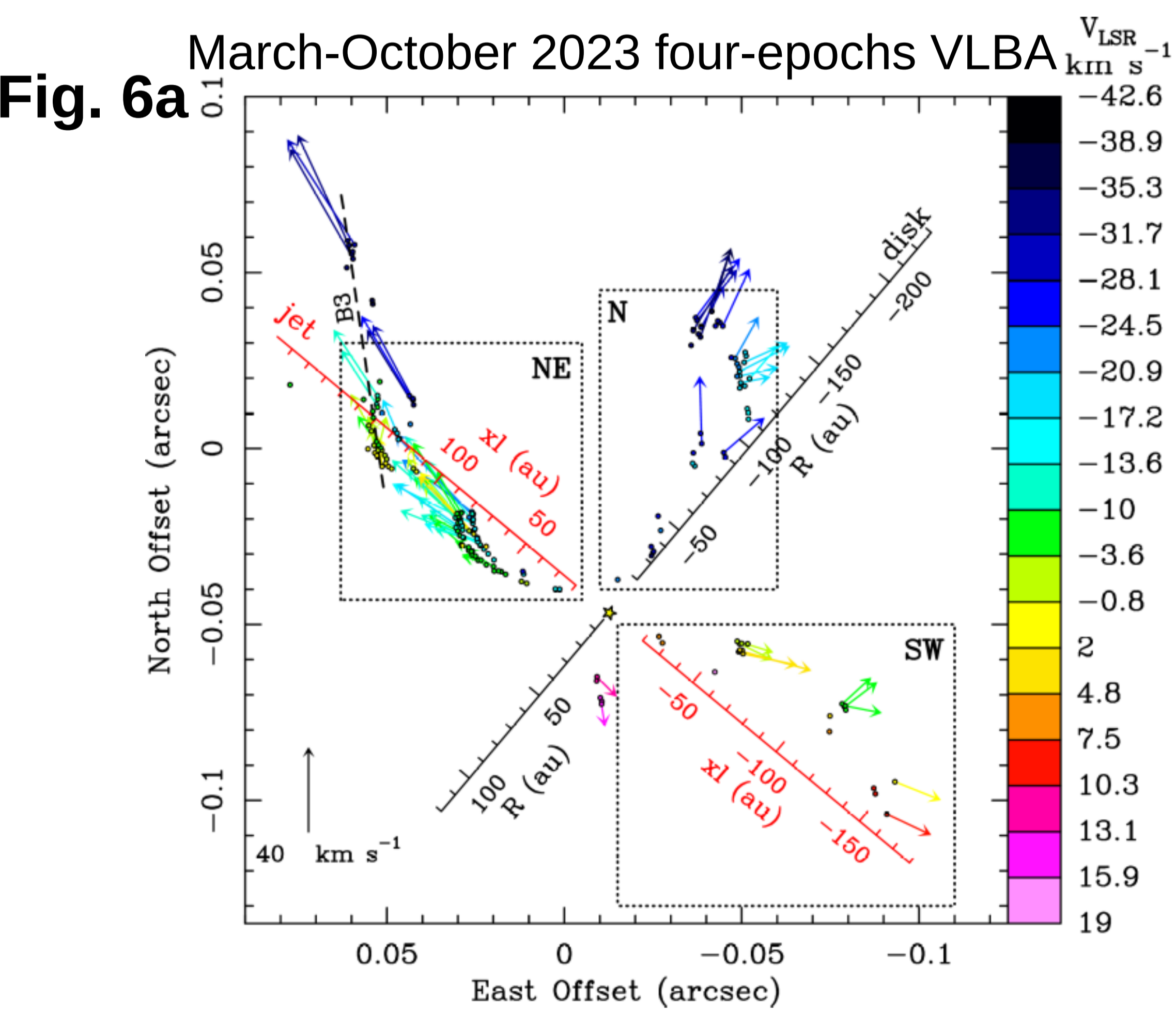


Fig. 6a

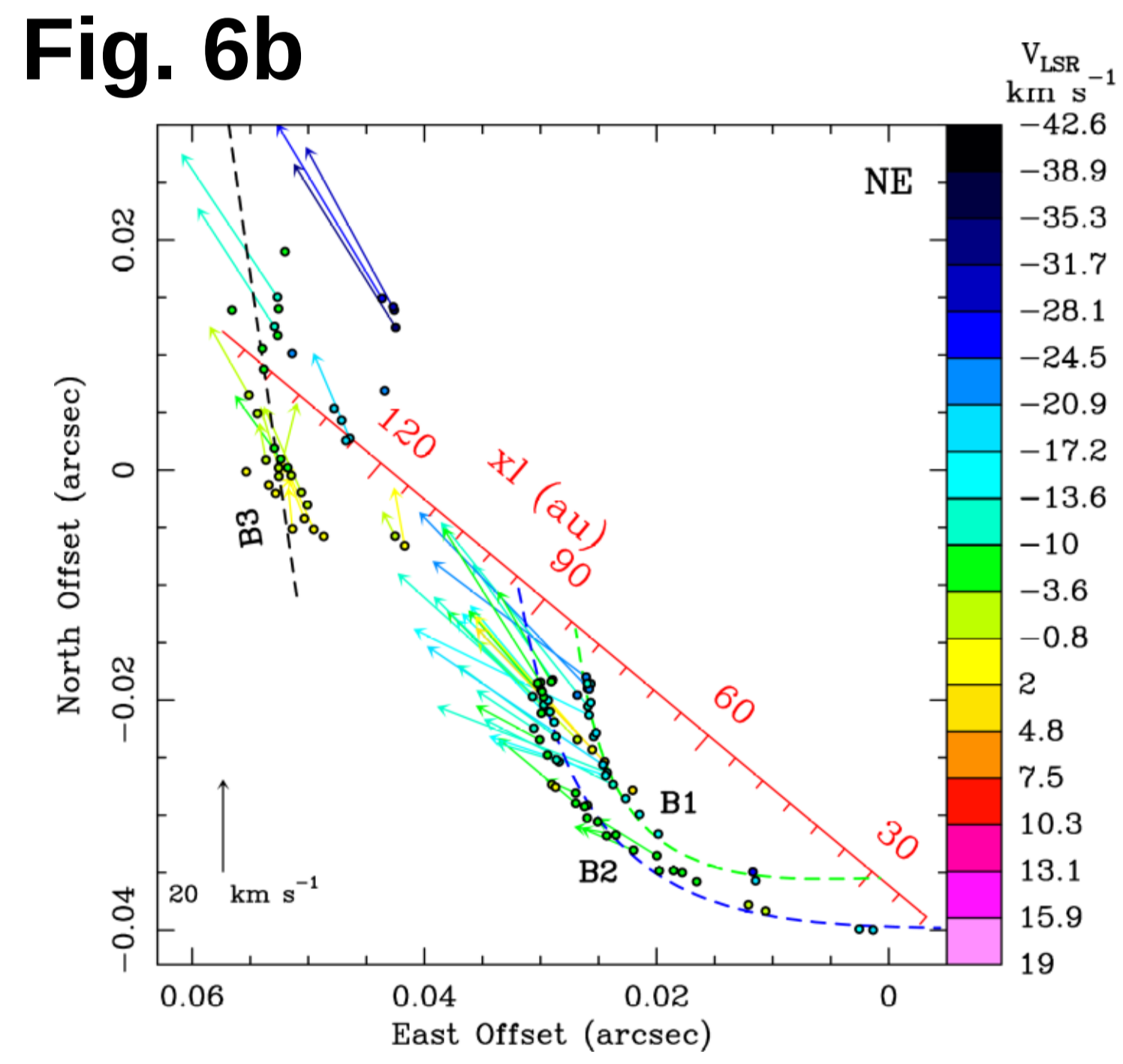


Fig. 6b

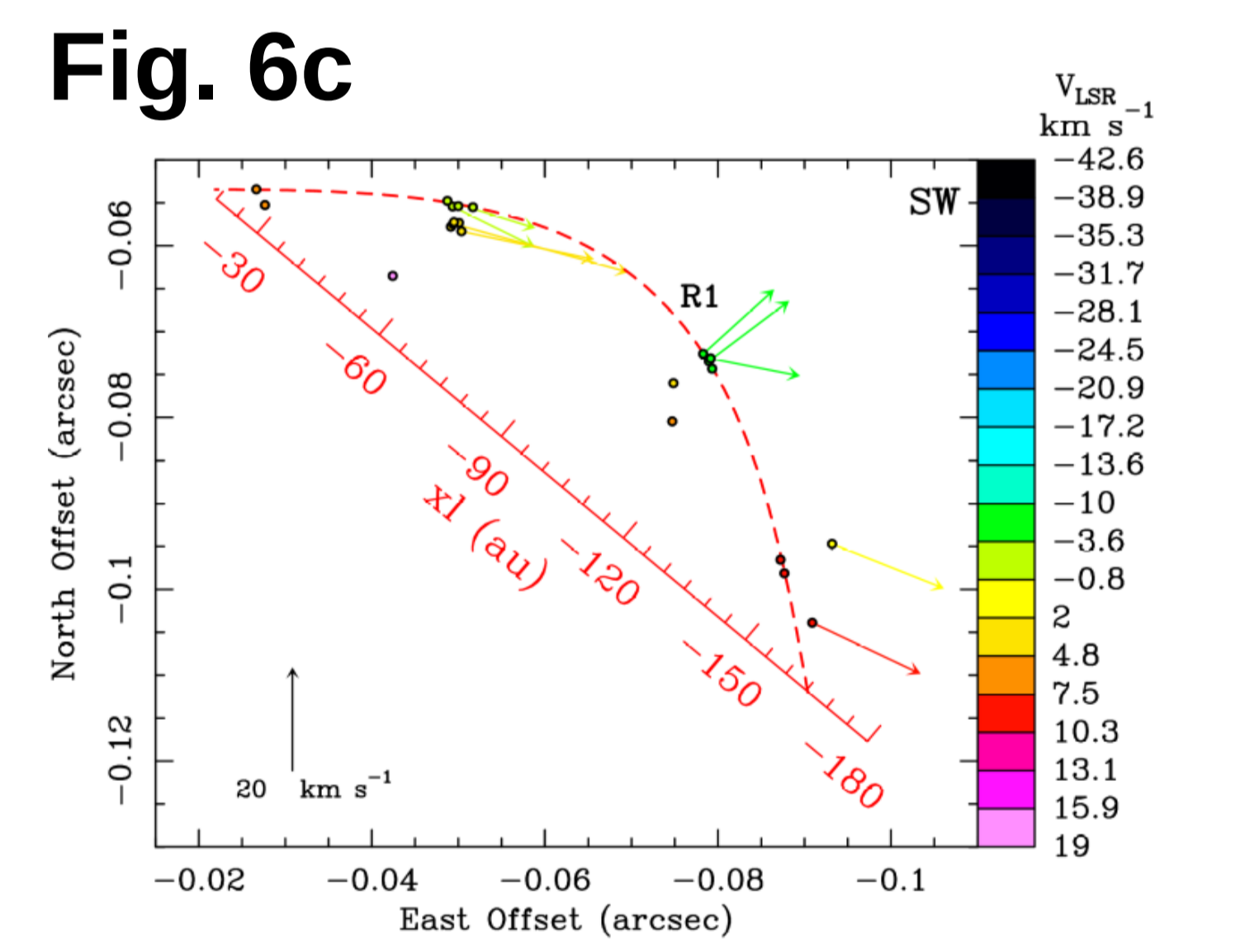


Fig. 6c

Fig. 7

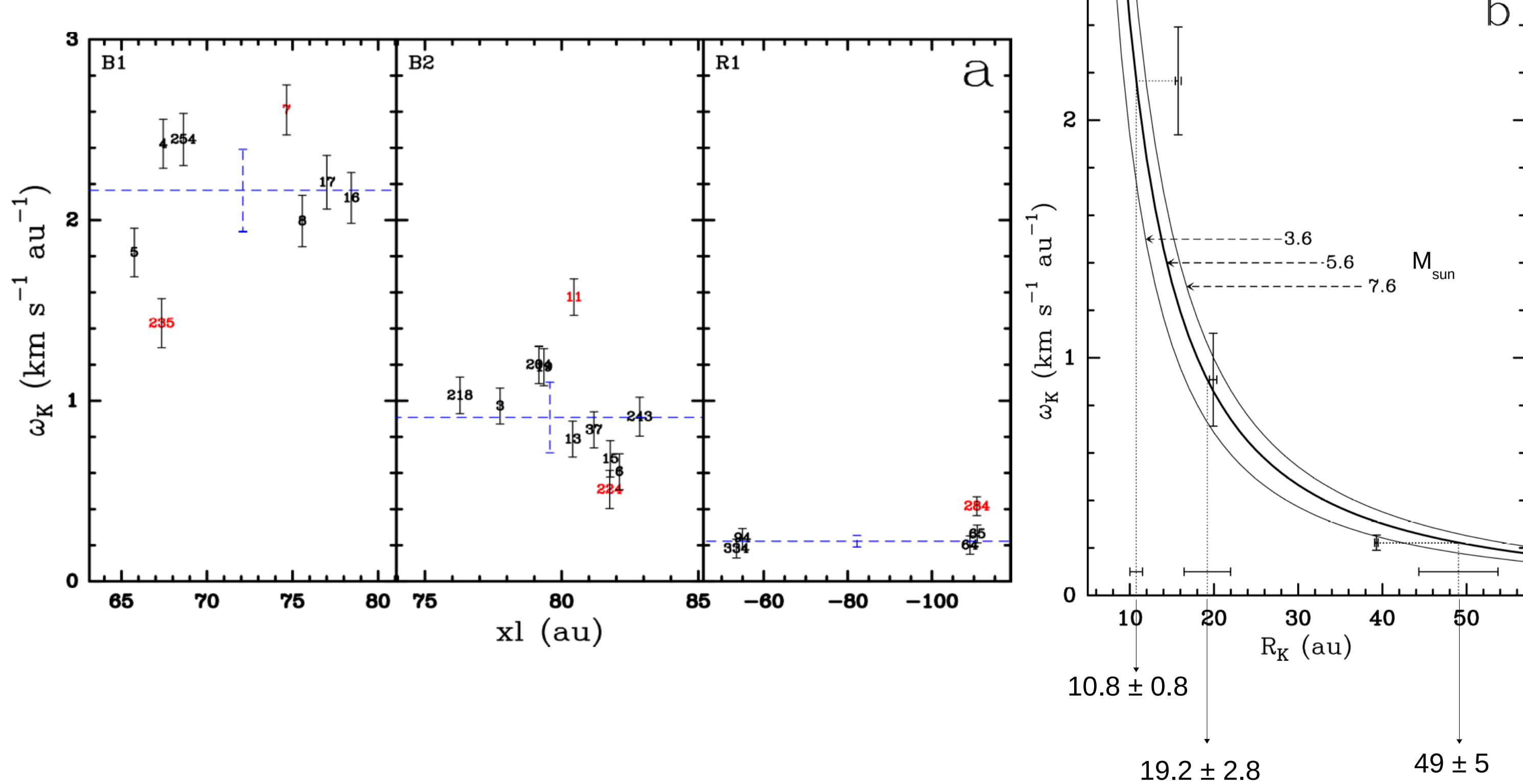


Table 1

Stream	Sinusoidal fit				
	R (au)	f_z (rad au ⁻¹)	xl_0 (au)	w_K (km s ⁻¹ au ⁻¹)	R_K (au)
B1	15.7 ± 0.3	0.047 ± 0.001	28.5 ± 0.9	2.17 ± 0.23	10.8 ± 0.8
B2	19.9 ± 0.4	0.034 ± 0.001	17.5 ± 0.9	0.91 ± 0.20	19.2 ± 2.8
R1	39.3 ± 0.2	0.018 ± 0.001	-165.4 ± 0.5	0.22 ± 0.03	49 ± 5

CONCLUSIONS

Using water masers, we can reliably determine the launching mechanism of protostellar winds and jets, testing the model applied to the data, too. In IRAS21078+5211, the high velocities (up to 60 km s^{-1}) observed close to the jet axis are inconsistent with acceleration due to (only) magnetic and/or thermal pressure, which produce typical terminal flow speeds $< 20 \text{ km s}^{-1}$. Magneto-centrifugal launching in a radially extended MHD DW appears the only viable process to explain the maser 3D velocity field in this source.