R27a Observations of the Molecular Gas in M82

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M82 is a nearby (3.5 Mpc) edge-on starburst galaxy with a galactic wind - large-scale outflow of ionized and neutral material from the galactic nucleus. In order to study the molecular gas outflow, we made ^{12}CO 1-0 observations with the Nobeyama 45-m telescope (Salak et al. 2013, PASJ 65). The data were recently combined with data from the Combined Array for Research in Millimeter-wave Astronomy (CARMA) to unveil the structure of the molecular gas outflow beyond the nuclear torus in unprecedented detail at $3.5''$ (60 pc) resolution (as part of the CArma-NObeyama Nearby-galaxies survey: CANON). The composite image reveals 50-pc bubbles and filaments of CO gas marked with increased velocity dispersion (> 40 km s^{-1}) and shocks.

In 2013, we made 3-mm molecular line observations with the 45-m telescope which allowed us to compare the excitation conditions in the nuclear and extra-planar regions of M82. ^{13}CO 1-0, C^{18}O 1-0, CN 1-0 and CS 2-1 were detected in the inner outflow. The 1-0 intensity ratios of ^{12}CO/^{13}CO and ^{13}CO/C^{18}O increase in the extra-planar gas compared to the central region; ^{12}CO/^{13}CO ratio is $\gtrsim 15$ in all investigated regions. Detection of weak CS 2-1 suggests that the molecular gas might preserve its dense component in the entrainment into the outflow, albeit surrounded by enlarged photodissociation regions (PDRs), hence reduced beam filling factor for dense clouds and reduced optical depth. This is supported by detection of the PDR tracer CN 1-0 with intensity only ≈ 4 times lower than in the nuclear torus. To disentangle the integrated observations of dense and diffuse cloud ensembles, we use non-LTE calculations.