R37c Large-field CO (J=1-0) observations of the starburst galaxy M 82

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We report large-scale mapping (15 x 17 arcmin^2) of the nearby starburst galaxy M 82 in CO (J=1-0) with the 45-meter telescope of the Nobeyama Radio Observatory. The observations were carried out in 2009 and 2010 with the BEARS receiver, which can observe 25 positions on the sky simultenously, in the on-the-fly mode. CO emission was detected up to 3 kpc away from the galactic center, including elongated structures which reveal streams of molecular gas, accompanied with double peaks in the CO spectra at several positions, as well as a 2-kpc molecular gas disk. Channel maps resolve an asymmetric stream which was formed most likely in a past tidal interaction with another galaxy. The 2-kpc molecular gas disk lies in the plane of the galaxy and apparently correlates with the spiral arms. Further, P-V diagrams clearly resolve the outflow of molecular gas up to at least 1 kpc perpendicular to the plane, driven by the galactic superwind. The integrated intensity of CO (J=1-0) is compared with that of higher rotational transitions in order to investigate the physical conditions in the molecular gas. A relatively high CO line intensity ratio of nearly 1 in (J=3-2)/(J=1-0) is found in the central region, whereas it decreases outwards, most sharply in the outflow. In addition to the kinematics of the molecular gas, probed with high velocity resolution, we use the formalism of radiative transfer to discuss the difference between the density and kinetic temperature in the four distinguished components of the gas: the nucleus, disk, asymmetric stream and outflow.