Suppression of E090 ghost lines from unwanted local oscillator harmonics by a LO filter

March 31, 2016 S.Navarro, C.Marka

Ghost lines in the EMIR 3 mm band arising from mixing of astronomical lines with the (unwanted) third harmonic of the local oscillator fundamental frequency (equal to $\frac{\nu_{\rm LO}}{2}$ for E090), comparable to ghosts seen in the 1 mm band in the past (cf. report on EMIR ghost lines, August 2014 and March 2015) were reported by J. Cernicharo after the E090 upgrade in November 2015. For the lowest possible tuning of the band with $\nu_{\rm LO}=82.03$ GHz, mixing of the 3rd harmonic of the fundamental LO frequency with the ¹²CO(1–0) line at 115.271 GHz creates a ghost at 74.256 GHz, which reaches ca. 3% of the original line's strength in vertical and 1.5% in horizontal polarization. For a 0.5 GHz higher local oscillator frequency, the ghost strength is a factor of about 10 smaller.

On March 22, 2016, a waveguide filter was installed for the 3 mm band local oscillator. Tests by injection of an artificial line showed that the ghost created by mixing with the 3rd LO harmonic is suppressed by at least -20 dB by the filter (upper limit due to limited dynamic range). An observation of DR21 with tuning $\nu_{\text{LO}}=82.03 \text{ GHz}$ without the LO filter shows the ghost line at 74.256 GHz with 0.7 K in V and 0.4 K in H (peaks of the original ¹²CO line: 35.8 and 38.9 K, respectively). After installation of the filter, the ghost line is not detected anymore down to the noise level of 0.04 K, corresponding to an additional suppression of the ghost by the filter of at least -12 dB (figure 1). The actual rejection is expected to be significantly better (-40 dB according to manufacturer's specifications; see also upper limit from artifical line injection), but could not be investigated in detail due to weather and time constraints.

In conclusion, the short tests of March 22nd indicate a correct operation of the newly installed LO filter for suppression of ghost lines induced by higher local oscillator harmonics in the 3 mm band.



Figure 1: ¹²CO(1–0) towards DR21 (black) and its ghost at 75.256 GHz for a tuning with $\nu_{\rm LO}$ =82.03 GHz, before (magenta) and after (red) installation of the LO filter, for vertical (left) and horizontal polarization (right). The right side temperature scale is valid for both ghost line setup with and without filter LO filter. Spectra were taken in position-switching mode with an off position 600" west of the source.

References

Kramer, Navarrini, Navarro, John, Cernicharo; August 2014; IRAM Report on ghost lines. Sievers, John, Navarro, Kramer; March 2015; Work report on ghost line observations with E150.