Polarimetric tests of E090 with orthomode transducer (OMT)

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1 Motivation

EMIR band 1 had a major update in November 2015. See commision report [2015b]. Not only the mixer was exchanged, but also the dual-horn system was changed to a single horn system and the linear (H and V) polarization splitting is produced by a ortho-mode transducer (OMT). From the laboratory we know that the splitting should be better than 20 db and therefore we do not expect any consequence for XPOL observations from the polarization splitting. On the other hand using a single horn instead of two different horns for H an V could improve the instrumental polarization. This is what we try to show in this report, i.e. to show that XPOL observations can be made with the same or maybe even lower instrumental polarization.

In order to easily compare with previous XPOL test observations (see [2015a]), we did a similar set of ON-OFF and OTF-Map observations of an unpolarized source over a large as possible range of elevations.

2 Observations

The observations were done during the night of 6th and 7th December, the weather was quite good with 3-5 mm H2O. We used only the E090, but configured VESPA with 2 parts for polarization, one 500 MHz wide part was connected to lower-outer subband at 72.6 GHz and the other 300 MHz wide part was connected to upper-outer sideband at 91.5 GHz. This way we could compare a window at the low frequency extension and compare it directly with a window configured at 'normal' frequencies. Uranus was observed using standard on-off's. Several on-off observations were followed by a small beam-map in Lambda and one in Beta. This was repeated until Uranus was setting.

3 ONOFF observations

We made a series of standard XPOL observations of Uranus over the elevation range from before the culmination at 59 degrees until 14 degrees. The result is summarized in Fig. 1. Here we have changed the sign of V-pol from the UO-band in the top panel. The instrumental polarization in Q and U is below 1%, i.e. very low. Only the circular polarization V shows a significant instrumental term of -2%. This is a higher value as found before (see e.g. [2015a]). This could be mainly due to that the double lobed structure seen before and usually expected, is now much more asymmetric, so that an on-off observation shows an significant result because the positive and negative lobes do not cancel out as well as before.

4 Maps

14 small maps on Uranus were done alternating in L and B. An average is shown in figure 2. The level of instrumental polarization is low (1 %)in Q and even lower in U (0.5%) The circular polarization V is mainly a peak at 2.5% and some indication of a second peak can be seen in the UO-band. Note that we

band	Stokes	pattern type	maxima, %		PA	remark
3mm	Q	irregular	-0.4	-1.5	~ 45	asymmetric double
	U	2–lobed	+0.2	-0.6	~ 45	weak double
	V	single	+2.0	+2.8	—	pos. lobe on axis

Table 1: Main characteristics of sidelobe patterns. PA gives the position angle of the pattern (direction to positive peak from (x,y) origin, whenever applicable).

also changed the sign for the circular polarization V for the UO band, as for the on-off results.
Tab. 1 summarizes the main characteristics of the maps.

5 Discussion

Introducing a OMT, and thus observing both H and V polarizations with a single horn, has improved the instrumental polarization seen by the E090. The On-Off observations show that we have improved Q and U but increased the V instrumental polarization. The maps show that the circular polarization has mostly one lobe and not two as seen before (see e.g. [2015a]). This is about the only result obtained with some certainty, since the polarized side-lobe structure in the maps are too weak to draw further conclusions.

Furthermore the maps of Uranus were averaged to show some of the side lobe structure in figure 2, and depending on were the instrumental polarization arises, the details of the side-lobe pattern could appear distorted. In order to observe the details of the side-lobes, the observations should be repeated using a stronger unpolarized source (e.g. Mars).

References

[2015a] Commissioning Report on XPOL using the New Optics, 19-Oct-2015 by Sievers et al..
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[2015b] EMIR upgrade of 3mm and 2mm bands: Astronomical Commissioning
http://www.iram.es/IRAMES/mainWiki/EmirforAstronomers?action=AttachFile&do=view&target=report-e0e1upgrades-15dec2015-v1.1.pdf

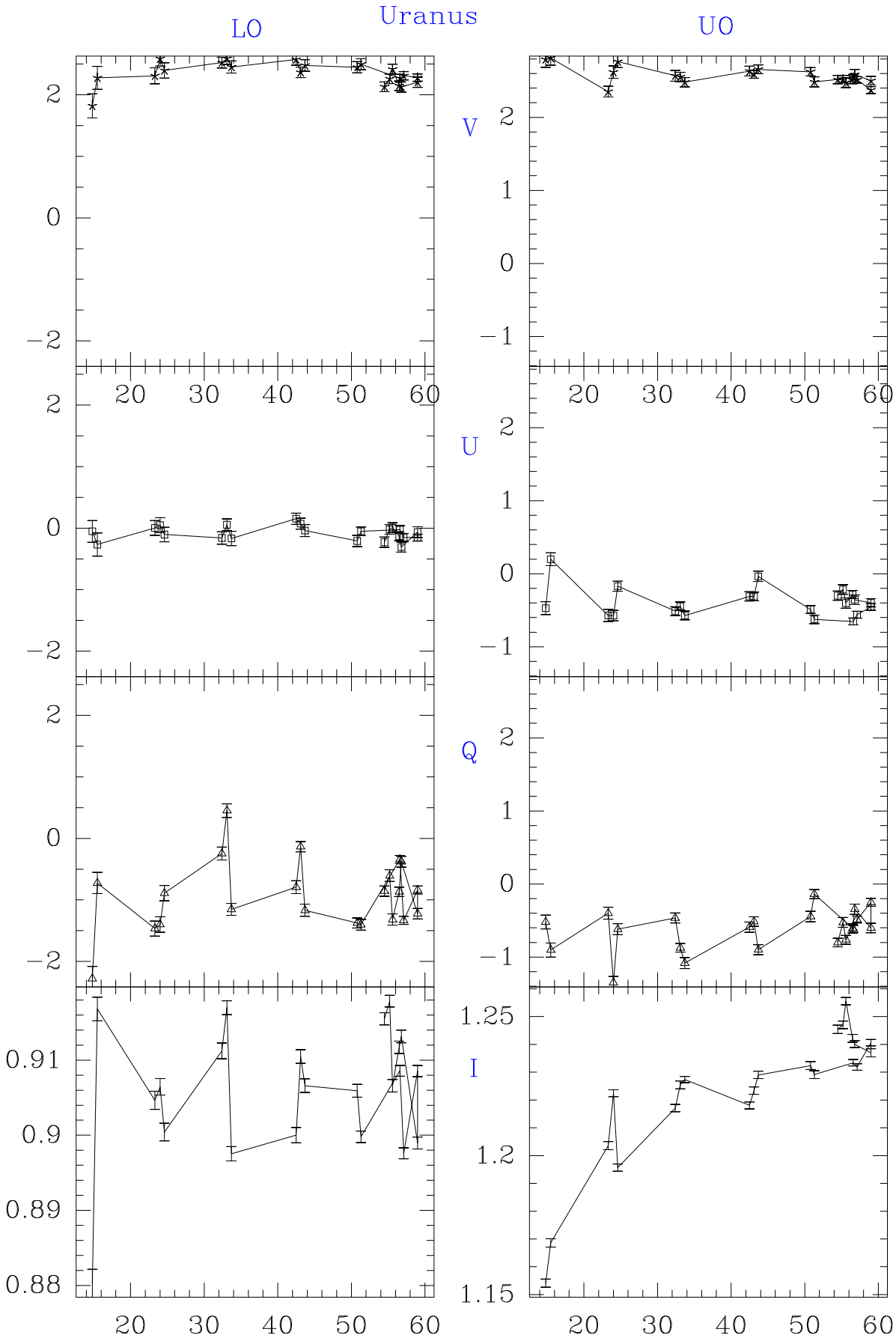

Figure 1: XPOL on-off observations of Uranus shown as a function of elevation. For each of the observed bands (LO at 72.6 and UO at 91.5 GHz) I, Q, U, and V are shown from bottom to top. I is on the Ta* scale in Kelvin. Q, U, and V are in percent. The sign was changed for V for the UO-band

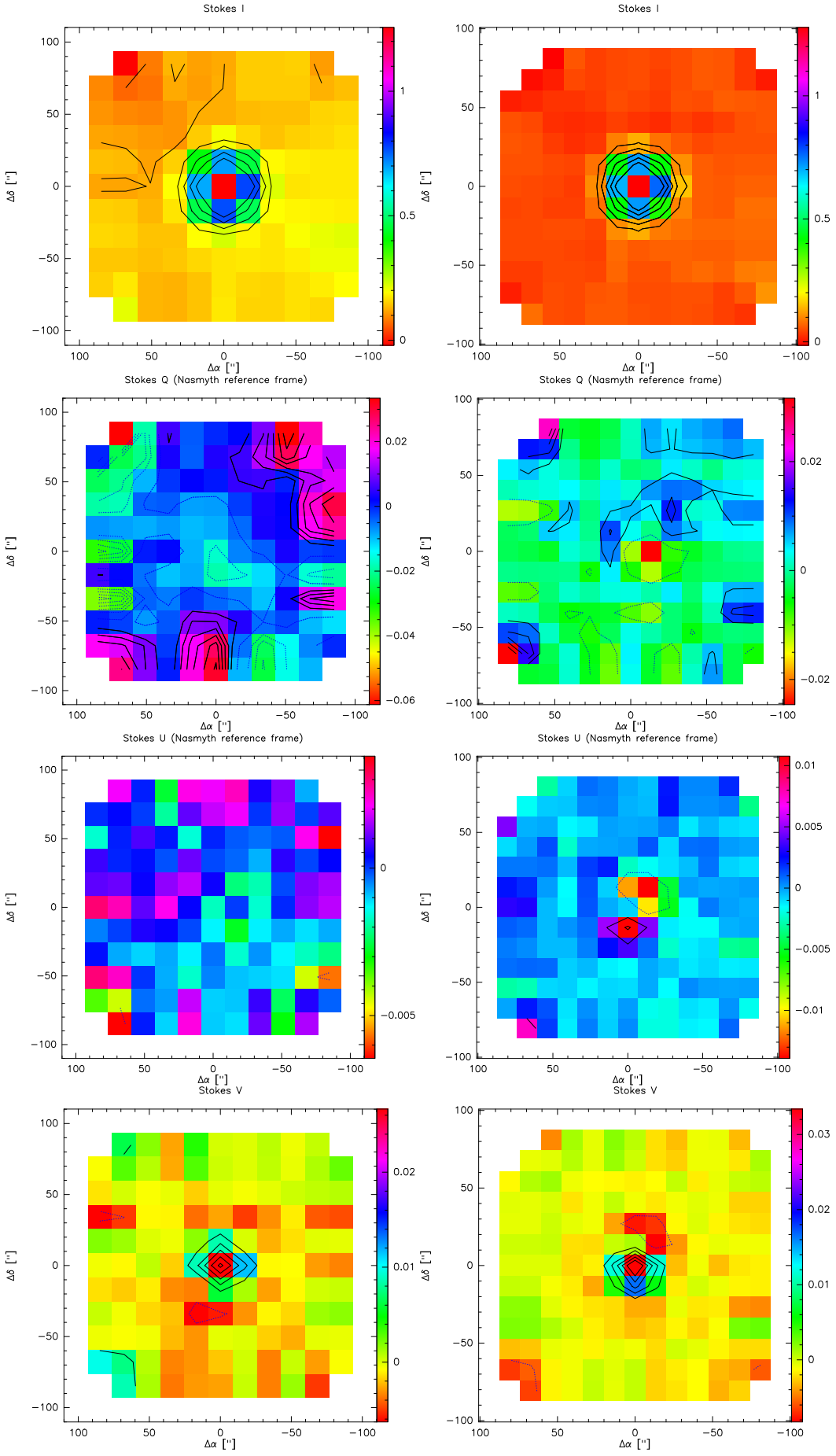

Figure 2: XPOL maps of Uranus (Stokes I, Q, U, and V) The LO-band at 72.6 GHz is shown on the left and the UO-band at 91.5 GHz on the right hand side. The axes are Azimuth, Elevation. All units are antenna temperatures. Contours for I are -5, 5, 10, 4. 50%, and for Q, U and V are at 3, 2.5, 2.0, ... 0.5 % positive and negative (dashed lines).