



ALMA Polarization

Commissioning and Verification Status

Kouichiro Nakanishi (Joint ALMA Observatory/NAOJ)

on behalf of *ALMA Polarization Commissioning Team*

H.Nagai (NAOJ), E.Fomalont, S.Coder (JAO),

R.Hills (Cambridge), G.Moellenbrock (NRAO),

E.Chapillon, Y.-W.Tang (ASIAA),



ALMA Polarization: Goal

- High sensitivity and high angular resolution polarization observation with both continuum and line at millimeter and sub-millimeter wavebands
- Requirements
 - measure linearly and circularly polarized fluxes down to 0.1% level of total flux
 - determine the position angle of linearly polarized flux better than 6 degrees



ALMA Polarization: Status

- Polarization observation capability was not opened at Cycle 0/1
- Commissioning and system/science verification activities are going on
- We are close to roll out ALMA Polarization, and it will be available in near future



Commissioning and Verification

- “*Polarization Commissioning Team*” is being in charge of commissioning and verification of this new capability
 - JAO member + experts of polarization observation from ALMA partners (EA/NA/EU)



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Instrumental polarization

$$\hat{V}_X = V_X + D_X V_Y$$

$$\hat{V}_Y = V_Y + D_Y V_X$$

Instrumental Polarizations (D terms): fraction of the input signal voltage in one polarization that leaks into the output of the other polarization.

$$\hat{V}_{X_m} \hat{V}_{X_n}^* = I + Q \cos(2\psi_m) + U \sin(2\psi_m)$$

$$\hat{V}_{Y_m} \hat{V}_{Y_n}^* = I - Q \cos(2\psi_m) - U \sin(2\psi_m)$$

$$\hat{V}_{X_m} \hat{V}_{Y_n}^* = \underline{I(D_{X_m} + D_{Y_n}^*)} - Q \sin(2\psi_m) + U \cos(2\psi_m) + iV$$

$$\hat{V}_{Y_m} \hat{V}_{X_n}^* = \underline{I(D_{Y_m} + D_{X_n}^*)} - Q \sin(2\psi_m) + U \cos(2\psi_m) - iV$$

Typical magnitude of instrumental polarization is an order of a few ~ several %, which is comparable to or larger than astronomical source polarizations!

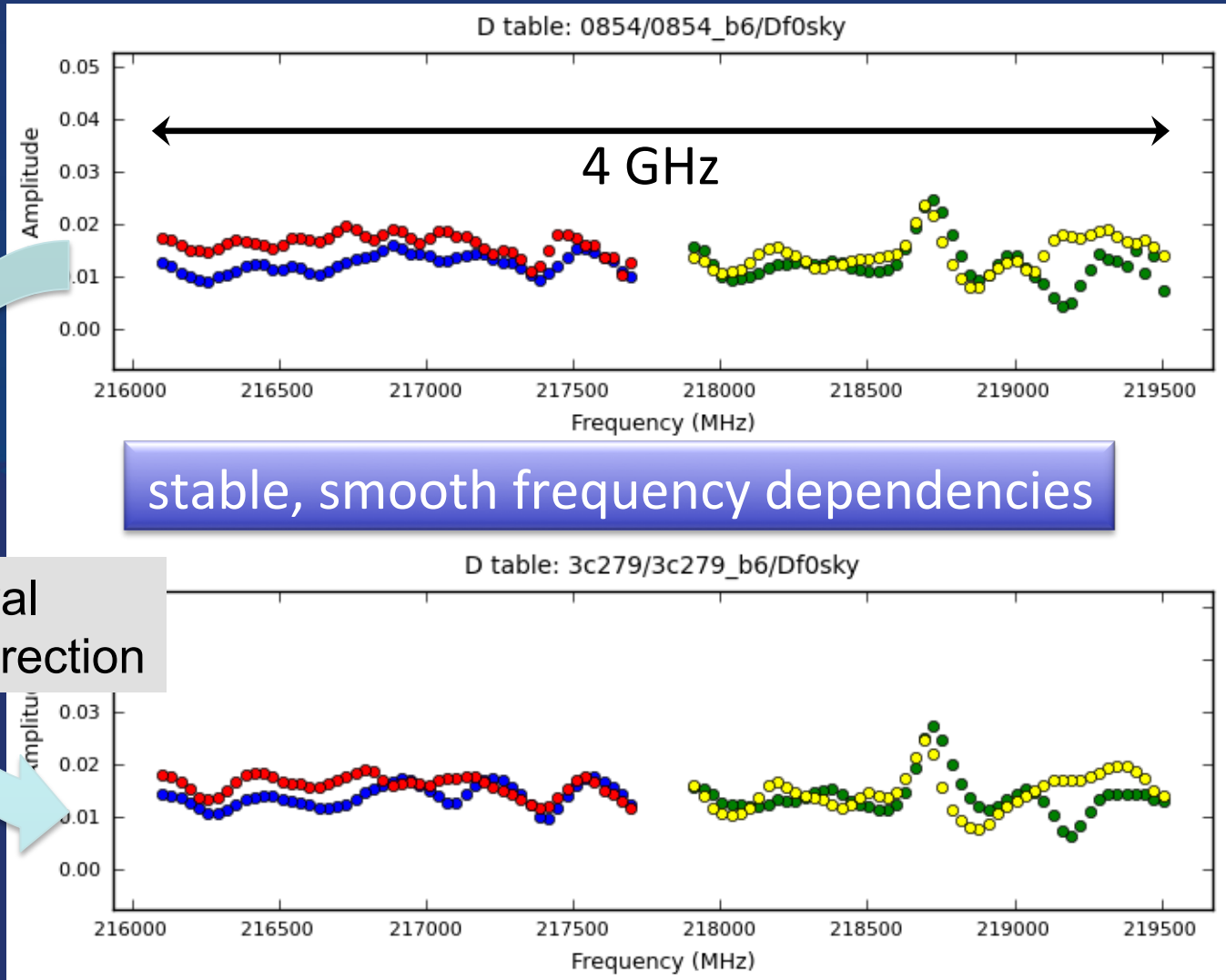


Instrumental polarization

- The polarization commissioning team has been investigating instrumental polarization properties
 - stability, frequency dependencies, and changes within a field of view (f.o.v.)
- Instrumental polarizations are quite stable
 - they are likely to be well calibrated at a center of f.o.v.
 - they do not change dramatically within a fraction of f.o.v.



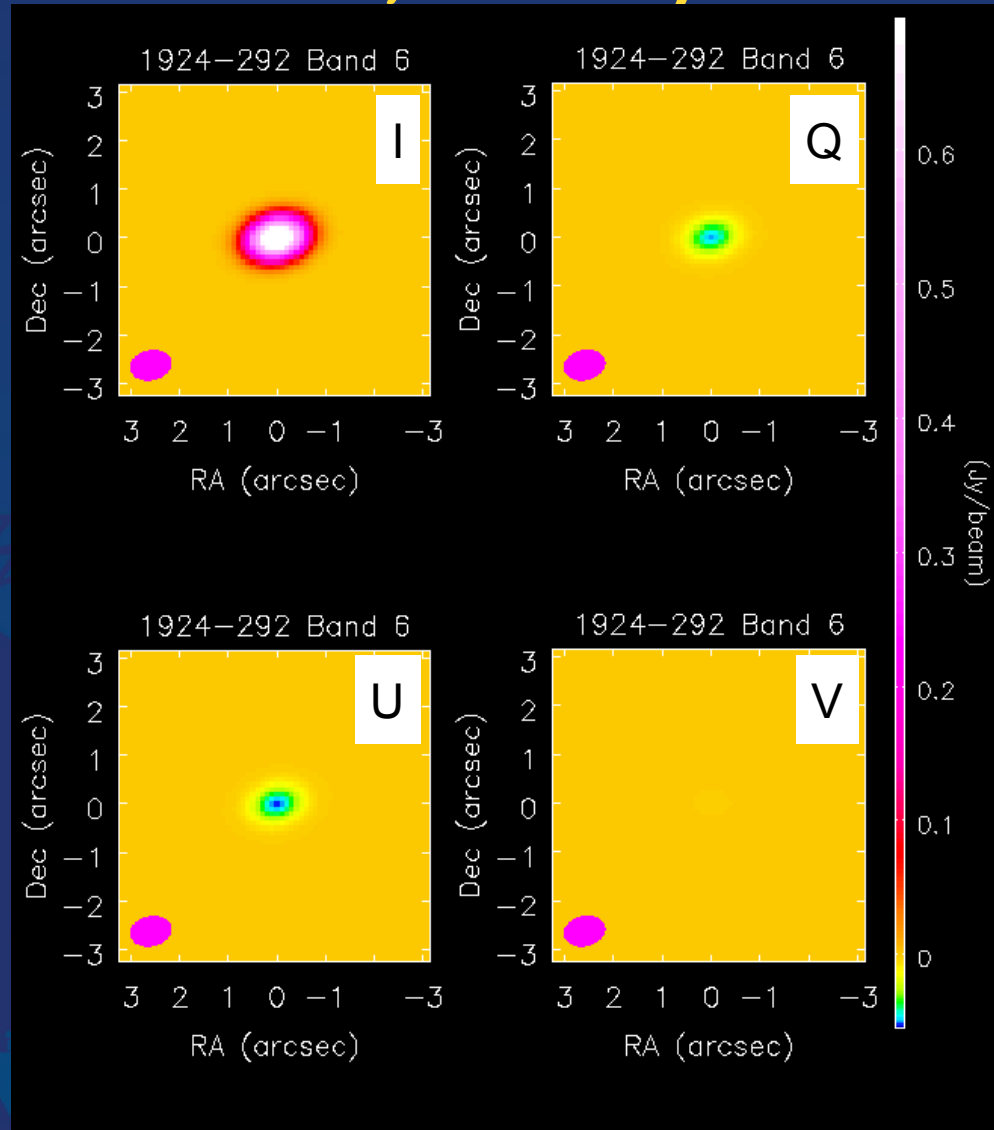
Instrumental polarization





Test data

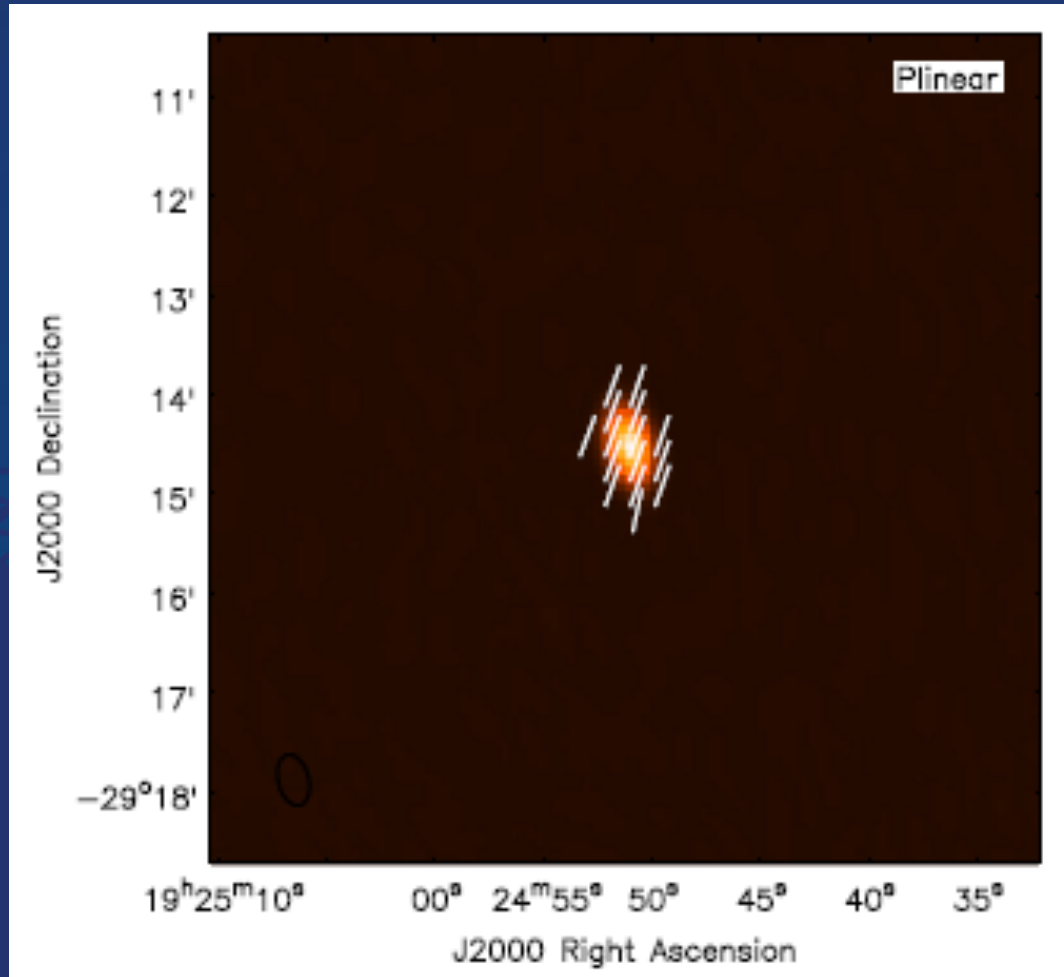
(QSO J1924-292, Band 6)





Test data

(QSO J1924-292, Band 3, P~6%)





Capability at near future (tentative!)

We will offer polarization observations in near future under limitations as follows;

- bands 3, 6, and 7 (*no band 9*)
- continuum only (*no line*)
 - (at a *standard* frequency in each observing band)
- spatially compact source
 - smaller than a fraction of field of view
 - single field w/12-m only (*no mosaic, no ACA*)
- linearly-polarized image only (*no circular*)
 - polarized flux of $\sim 0.5\%$ of the total flux can be imaged



The Atacama Large Millimeter/submillimeter Array (ALMA), an international astronomy facility, is a partnership of Europe, North America and East Asia in cooperation with the Republic of Chile. ALMA is funded in Europe by the European Organization for Astronomical Research in the Southern Hemisphere (ESO), in North America by the U.S. National Science Foundation (NSF) in cooperation with the National Research Council of Canada (NRC) and the National Science Council of Taiwan (NSC) and in East Asia by the National Institutes of Natural Sciences (NINS) of Japan in cooperation with the Academia Sinica (AS) in Taiwan. ALMA construction and operations are led on behalf of Europe by ESO, on behalf of North America by the National Radio Astronomy Observatory (NRAO), which is managed by Associated Universities, Inc. (AUI) and on behalf of East Asia by the National Astronomical Observatory of Japan (NAOJ). The Joint ALMA Observatory (JAO) provides the unified leadership and management of the construction, commissioning and operation of ALMA.