



#### High resolution analysis of chromospheric fine structure with ALMA

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## Agenda

- Topic 1: Full-disc solar ALMA image,
   λ=1.21 mm: general look
- Topic 2: Full-disc solar ALMA image,
   λ=1.21 mm: coronal bright points
- Topic 3: Interferometric ALMA image, λ=3.0 mm: fine structures & series of images ("movie")
- Conclusions
- Acknowledgements

# Topic 1: Full-disc solar images, general look

Identification of solar structure in full disc ALMA images
single dish, total power, 18 December 2015
λ=1.21 mm, 248 GHz, Band 6
Brajša et al. (2017a)

## SDO/AIA, 18 December 2015, $\lambda = 170 \text{ nm}; \text{AR}, \text{SS}$



#### NSO, NISP, Cerro Tololo, 18 December 2015, Hα; AR, SS, FIL



20:12 UT

#### SDO/AIA, 18 Dec. 2015, λ=17.1nm, λ=30.4nm, λ=21.1nm; AR, CH



#### SDO/AIA, 18 December 2015, λ=30.4 nm; AR, FIL, IL



#### SDO/HMI, 18 December 2015; IL, AR1: B<sub>max</sub>≈1000 G; SS: B<sub>max</sub>=1500-2500 G



## ALMA, 18 December 2015, λ=1.21 mm, 248 GHz, Band 6, Rol



Structure	r	$T_b(QS)$	n(QS)	$T_b(\text{structure})$	n(structure)	$\Delta T_b = T_b(\text{structure}) - T_b(\text{QS})$
	(pixels)	(K)	(pixels)	(K)	(pixels)	(K)
QS	0	$6040 \pm 70$	78	$6040 \pm 70$	78	0
SS	77	$6170 \pm 140$	2833	$6080 \pm 210$	136	-90
AR1	105	$6240 \pm 150$	2832	$7250 \pm 210$	3048	+1010
IL	147	$6300 \pm 160$	2833	$6130 \pm 160$	897	-170
PR (FIL1)	229	$6460 \pm 160$	2824	$6350 \pm 110$	154	-110
CH1	273	$6590 \pm 140$	2833	$6540 \pm 130$	2804	-50

- QS Quiet Sun
- SS Sunspot
- AR Active Region
- IL Inversion magnetic line
- PR (FIL) Prominence on the disc
- CH Coronal Hole
- r relative distance from the disc center
- σ<sub>av</sub>(T<sub>b</sub>) ≈ 150 K
- Iimb brightening ≈ 10 %

Topic 2: Full-disc solar images: coronal bright points

- Can coronal bright points be seen in full disc ALMA images of the Sun ?
- single dish, total power, 18 December 2015
- λ=1.21 mm, 248 GHz Band 6
  Brajša et al. (2017a)

# Coronal bright points, SDO/AIA, 19.3 nm, 56 structures



#### He 1083 nm dark points, NSO/SOLIS, Tucson, assoc. rate = 75 %



#### ALMA, $\lambda$ =1.21 mm, 248 GHz, assoc. rate = 82 %



## Zoom in, ALMA, d ≈ 490 Mm



## Zoom in, SDO/HMI



## Topic 3: Interferometric images, fine structures

- What are small bright structures seen in high resolution interferometric images ?
- λ=3 mm, 100 GHz, Band 3, 16 December 2015
- Sunspots ?
- Brajša et al. (2017b)

# ALMA, 16 December 2015, $\lambda$ =3 mm, 100 GHz Band 3



# NSO/SOLIS, H-alpha wing, Tucson



# SDO/HMI, magnetogram



## SDO/AIA, 170 nm



# SDO/AIA, 30.4 nm



# SDO/AIA, 19.3 nm



### Conclusions

- pointing and overlaying (coalignment) of ALMA images
   with other images → successful, TP (≈5") & INT (≈1")
- INT image reconstruction  $\rightarrow$  correct
- ARs  $\rightarrow$  bright in B6 & B3
- sunspot umbra  $\rightarrow$  dark in B6, but  $\rightarrow$  bright in B3
- filaments (on disc) and CHs are not discernible against the QS background
- Iarge-scale elongated dark structures in B6 → inversion lines of the magnetic field
- o coronal bright points → He 1083 dark points → ALMA B6 (TP) bright points; strongly correlated with magnetograms
- small bright ALMA B3 (INT) structures  $\rightarrow$  H $\alpha$  dark points
  - → magnetograms → UV continuum

limb brightoning

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