



Report from the event supported by RadioNet

TITLE *Centimetre-Sub-Millimetre Q&U (and V) Workshop (QUESO)*

DATE: *25-27 OCTOBER 2017*

LOCATION: *GARCHING B. MÜNCHEN, GERMANY*

MEETING WEBPAGE: *<https://www.eso.org/sci/meetings/2017/QUESO2017.html>*

HOST INSTITUTE: *EUROPEAN SOUTHERN OBSERVATORY (ESO)*

**RADIONET
BENEFICIARY / NO:** *ESO / 13*

Report:

1. SCIENTIFIC SUMMARY

Full polarization observation has become routine at the Karl G. Jansky Very Large Array (JVLA). It will likewise become straightforward and standard for the Atacama Large Millimeter/submillimeter Array (ALMA) as well as other modern observational facilities in the centimetre, millimetre, and submillimetre bands. The full polarisation image and image cubes produced thanks to the revolutionary sensitivity of the modern instruments will enable novel observational results, precision measurements and theoretical ideas in various scientific fields. Very excitingly, the excellent site of ALMA is now opening opportunities for carrying out polarization studies at very high frequency.

The aim of the workshop was therefore to bring together leading and future science users, observatory calibration experts and software developers from a broad range of research fields making use of polarimetric techniques in the approximate frequency range 5-1000 GHz. This range was deliberately restricted in order to focus attention on common problems and to promote cross-fertilisation between different subject areas.

The majority of participants came from the RadioNet science, engineering and observatory communities. The meeting provided an opportunity for the polarimetric community within RadioNet to develop collaborations, understand the latest technological developments and decide on common priorities for the future. A few experts from outside the RadioNet umbrella were invited to provide an external perspective.

The meeting began with two extended presentations on polarimetric techniques for high-frequency interferometry (Moellenbrock, Marti-Vidal).

A major theme of the meeting was the role of magnetic fields in star formation at high (Zhang, Pattle, Soam, Pillai) and low (Maury, Galametz, Valdivia) mass, as this can only be constrained by polarimetric observations. The general view was that dynamical dominance of the magnetic field was rare, but not unknown. Methods for estimating the field strength (Chandrasekhar-Fermi, maser polarization, Zeeman splitting) were valid in different regions and were therefore difficult to cross-check. The range of relevant physics was extensive, with magnetic braking, grain alignment by radiative and mechanical effects as well as magnetic fields and radiative transport all requiring further study.

Multi-wavelength observations of polarized emission from protoplanetary disks also revealed complications in the underlying physics. Three different polarizing mechanisms may be important: alignment of dust grains by magnetic fields; alignment by radiation and self-scattering (Kataoka). Fitting of ALMA data from 0.87 to 3 mm suggests that the grain sizes are much smaller than those derived from the spectrum alone, with important implications for planet formation.

Magnetic fields are also important in evolved stars, potentially driving the axisymmetric outflows in planetary nebulae. Observations of the Zeeman effect in maser polarization (Humphreys) suggests that the fields in the envelopes of evolved stars are indeed dynamically important, falling off with radius as expected for a toroidal geometry.

Measurement of Faraday rotation at mm wavelengths in the cores of active galactic nuclei is emerging as an important probe of the accretion rate, following early work on the Galactic Centre. Detections were presented for M87 and 3C273 (Asada, Hovatta); the non-detection in Centaurus A (Nagai) may be a consequence of orientation.

An old problem, relevant both to AGN jets and star formation, is how to distinguish between vector-ordered and disordered, but anisotropic field topologies: both are capable of producing high degrees of polarization. This was considered both in the AGN case and for Gamma-ray burst sources (Mundell). The degree of field ordering may also help to distinguish between particle acceleration mechanisms, for example in the hot-spots of radio galaxies (Oriente).



Although the main theme of the workshop was interferometric imaging of polarization, observations of the cosmic microwave background were also discussed. There are well-known and exciting applications of CMB observations (including the potential detection of cosmological B-modes) but also a number of synergies, both observational (polarized point sources, foreground subtraction) and technical (improved lens materials for mm-wave receivers).

The meeting served a valuable purpose in identifying priorities for future instrumental developments. In rough order of importance, these were:

- Very accurate circular polarization calibration in continuum and line (Zeeman effect).
- Improved efficiency of polarization calibration, avoiding the need for large parallactic angle rotation during an observation.
- Wider frequency coverage (e.g. ALMA Bands 8 – 10)
- Lower systematics for measurement of linear polarization, both to measure polarization fractions $<0.1\%$ in protoplanetary disks and to achieve high dynamic range for I.
- Polarization calibration over the primary beam, for example using Mueller matrix methods. This is essential for ALMA polarization mosaics.
- These considerations will be directly relevant for all high-frequency instruments capable of measuring polarization (single-dish and interferometric), including many facilities supported by RadioNet: Effelsberg, Pico Veleta, NOEMA, e-MERLIN and especially ALMA.

It was agreed that a White Paper on high-frequency polarization priorities, emphasizing RadioNet facilities, should be produced following the meeting and submitted to the arXiv preprint server.

2. AGENDA OF THE EVENT

Wednesday, Oct 25

13:30 Barcons, Xavier Welcome by the ESO DG

Overview

13:40 Marti-Vidal, Ivan NEW-GENERATION INTERFEROMETRIC POLARIMETRY ([DOI 10.5281/zenodo.1043180](https://doi.org/10.5281/zenodo.1043180))

14:20 Moellenbrock, George Synthesis Polarimetry Calibration ([DOI 10.5281/zenodo.1038085](https://doi.org/10.5281/zenodo.1038085))

Star Formation/Galactic

15:00 Krishnan, Hariharan Polarization Measurements of Solar Radio Transients Associated with Coronal Mass Ejections ([DOI 10.5281/zenodo.1038075](https://doi.org/10.5281/zenodo.1038075))

15:15 Break

15:35 Zhang, Qizhou Magnetic Fields and Star Formation ([DOI 10.5281/zenodo.1038115](https://doi.org/10.5281/zenodo.1038115))

16:15 Pattle, Katherine Latest results from BISTRO ([DOI 10.5281/zenodo.1038095](https://doi.org/10.5281/zenodo.1038095))

16:30 Soam, Archana SCUBA-2 Polarization Measurements for Mapping Magnetic Fields in Ophiuchus-B region

16:45 Pillai, Thushara POLSTAR survey: Magnetic fields in Pristine to Cluster Forming Filaments

17:00 Tomisaka, Kohji Structures of Magnetically-Supported Filaments and their Appearance in the Linear Polarization ([DOI 10.5281/zenodo.1038105](https://doi.org/10.5281/zenodo.1038105))

17:15 Zhang, Heshou Tracing magnetic fields with the polarization of submillimeter lines ([DOI 10.5281/zenodo.1038113](https://doi.org/10.5281/zenodo.1038113))

Reception

Thursday, Oct 26

Star Formation/Galactic

| | | |
|-------|------------------------|--|
| 09:00 | Humphreys, Liz | Evolved Stars, Masers and Polarization (DOI 10.5281/zenodo.1042451) |
| 09:40 | Wiesemeyer, Helmut | In the quest for Stokes V - science cases and technical challenges (DOI 10.5281/zenodo.1038109) |
| 09:55 | Myserlis, Ioannis | High precision linear and circular polarimetry. Sources with stable Stokes Q,U & V in the GHz regime (DOI 10.5281/zenodo.1038089) |
| 10:10 | Peest, Peter Christian | Implementing polarization in 3D MCRT codes (DOI 10.5281/zenodo.1038097) |
| 10:25 | | Break |
| 10:55 | Maury, Anaëlle | Observations of polarized dust emission in protostars: how to reconstruct magnetic field properties? (DOI 10.5281/zenodo.1038083) |
| 11:15 | Galamez, Maud | The magnetic structure of Class 0 protostars (DOI 10.5281/zenodo.1038063) |
| 11:30 | Valdivia, Valeska | Towards realistic predictions of mm/sub-mm polarized dust emission (DOI 10.5281/zenodo.1038197) |
| 11:45 | | Discussion |
| 12:30 | | Lunch |

Extragalactic/Jets

| | | |
|-------------|---------------------------|---|
| 13:30 | Asada, Keiichi | ALMA and SMA polarimetric observation towards M87 (DOI 10.5281/zenodo.1038053) |
| 14:10 | Orienti, Monica | ALMA polarization observations of the particle accelerators in the peculiar hot spot 3C 445 South (DOI 10.5281/zenodo.1038093) |
| 14:25 | Hovatta, Talvikki | SPRITE: the Stokes Polarimetric Radio Interferometer for Time-domain Experiments (DOI 10.5281/zenodo.1038071) |
| 14:40 | Mundell, Carole | Do Magnetic Fields drive high-energy explosive transients? (DOI 10.5281/zenodo.1038087) |
| 14:55 | Kim, Jae-Young | Spatially resolved origin of mm-wave linear polarization in the nuclear region of 3C 84 |
| 15:10 | | Break |
| 15:30 | Nagai, Hiroshi | ALMA Polarimetric Observations of Centaurus (DOI 10.5281/zenodo.1038091) |
| 15:45 | Galluzzi, Vincenzo | Multi-frequency polarimetry of a complete sample of PACO radio sources (DOI 10.5281/zenodo.1038065) |
| 16:00 | Angelakis, Emmanouil | QUVI multi-frequency radio polarisation monitoring of Fermi blazars; Physical processes in AGN jets (DOI 10.5281/zenodo.1038051) |
| 16:15 | Agudo, Ivan | POLAMI: Full-Polarization Monitoring of AGN at Millimeter Wavelengths with the IRAM 30m Telescope (DOI 10.5281/zenodo.1038049) |
| 16:30 | Nikiel-Wroczyński, Błażej | I am the one and only: regular magnetic field in the IGM of the Stepan's Quintet (DOI 10.5281/zenodo.1038111) |
| 16:45-17:45 | | Discussion |
| 19:00-21:00 | Workshop Dinner | Location is Augustiner, near downtown Garching |

Friday, Oct 27

Disks

- 09:00 Kataoka, Akimasa millimeter-wave polarization of protoplanetary disks: alignment or scattering? ([DOI 10.5281/zenodo.1038073](https://doi.org/10.5281/zenodo.1038073))
- 09:40 Girart, Josep Miquel Millimeter dust polarization from a disk around massive YSO ([DOI 10.5281/zenodo.1038067](https://doi.org/10.5281/zenodo.1038067))
- 09:55 Sanna, Alberto ALMA resolves a disk-jet system around an O-type young star
- 10:10 de Boer, Jos Polarimetric imaging of protoplanetary disks from the optical to sub-mm ([DOI 10.5281/zenodo.1038057](https://doi.org/10.5281/zenodo.1038057))
- 10:25 Break

CMB/Large Scale

- 10:45 Bryan, Sean Frontiers in Cosmology with the Cosmic Microwave Background ([DOI 10.5281/zenodo.1038055](https://doi.org/10.5281/zenodo.1038055))
- 11:25 Siebenmrogen, Ralf Large Interstellar Polarisation Survey: The dust elongation when combining optical-submm polarisation ([DOI 10.5281/zenodo.1038101](https://doi.org/10.5281/zenodo.1038101))
- 11:40 di Serego Alighieri, Sperello Using ALMA to calibrate the polarization angle at CMB frequencies ([DOI 10.5281/zenodo.1038059](https://doi.org/10.5281/zenodo.1038059))
- 11:55 Levrier, François Polarized thermal emission from Galactic dust as seen by Planck ([DOI 10.5281/zenodo.1045797](https://doi.org/10.5281/zenodo.1045797))
- 12:10 Enßlin, Torsten The Milky Way in Circular Polarization - a forecast ([DOI 10.5281/zenodo.1038061](https://doi.org/10.5281/zenodo.1038061))
- 12:25 Lunch
- 13:30 Slagter, Reinoud Evidence of Cosmic Strings by the Observation of the Alignment of Quasar Polarization Axes ([DOI 10.5281/zenodo.1038103](https://doi.org/10.5281/zenodo.1038103))
- 13:45 Pelgrims, Vincent Extreme-scale alignments of quasar optical polarizations and Galactic dust contamination ([DOI 10.5281/zenodo.1038099](https://doi.org/10.5281/zenodo.1038099))

Summary/Overview

- 14:00-15:00 Robert Laing Summary and Final Discussion

3. PARTICIPANTS

There were 62 registered participants. In addition, some astronomers from the Garching campus (ESO/MPE/MPA) attended parts of the meeting.

Of the registered attendees, 77% came from Europe (Germany, Spain, UK, Italy, France, Finland, Sweden, Poland, Belgium and the Netherlands). Of the remainder, the majority were from East Asia (Japan, Korea, Taiwan), with others based in the United States, Brazil, India and Iran.

There were 7 invited speakers (1 female, 7 male) from institutions in Europe (2), East Asia (2) and North America (3).

24% of talk submissions were from women, with the same fraction allocated.

Roughly one third of the participants were students (Masters/Doctoral) or junior postdoctoral researchers. The remainder include tenured and tenure-track faculty members, observatory support and research institute staff.

The full list of attendees is attached.



4. RADIONET FINANCIAL CONTRIBUTION

We used the support from RadioNet to subsidize the travel of three postdocs and students attending the workshop, in addition to waiving their registration fees using internal ESO funding. This was to maximize participation of junior, underrepresented scientists.

Those we chose for support were: Hariharan Krishnan (postdoc, NCRA-TIFR, India); Samaneh Eftekhari (Masters student, IPM, Iran) and Seyed Azim Hashemi (Masters student, Sharif University of Technology, Iran).

5. PUBLICATIONS

The presentations are linked to the conference agenda at <https://www.eso.org/sci/meetings/2017/QUESO2017/program.html>, have DOIs and are also indexed through the Smithsonian/NASA Astronomical Data System.

| | Participant | Home Institution |
|----|-------------------------------|--|
| 1 | Andreani, Paola | ESO, Germany |
| | Agudo, Ivan | IAA-CSIC, Spain |
| | Angelakis, Emmanouil | Max-Planck-Institut für Radioastronomie, Germany |
| | Asada, Keiichi | ASIAA, Taipei |
| | Avison, Adam | Jodrell Bank Centre for Astrophysics, UK |
| | Böhm, Torsten | CNRS/OMP/IRAP, France |
| | Bryan, Sean | School of Earth and Space Exploration, Arizona State University, USA |
| | de Boer, Jos | Leiden Observatory, The Netherlands |
| | De Breuck, Carlos | ESO, Germany |
| | de Oliveira Alves, Felipe | Max-Planck-Institut für extraterrestrische Physik, Germany |
| 11 | di Serego Alighieri, Sperello | INAF - Osservatorio Astrofisico di Arcetri, Italy |
| | Eftekhari, Samaneh | Institute for Research in Fundamental Sciences (IPM), Iran |
| | Enßlin, Torsten | Max-Planck-Institut für Astrophysik (MPA), Germany |
| | Galametz, Maud | CEA, Saclay, Service d'Astrophysique, France |
| | Galluzzi, Vincenzo | Di.FA. (University of Bologna) & INAF-IRA, Italy |
| | Girart, Josep Miquel | Institut de Ciències de l'Espai, Spain |
| | Hashemi, Seyed Azim | Sharif University of Technology, Physics department, Iran |
| | Hatziminaoglou, Evanthia | ESO, Germany |
| | Herpin, Fabrice | Laboratoire d'Astrophysique de Bordeaux, France |
| | Hovatta, Talvikki | Tuorla Observatory, University of Turku, Finland |
| 21 | Humphreys, Liz | ESO, Germany |
| | Kataoka, Akimasa | National Astronomical Observatory of Japan, Japan |
| | Jimenez Rosales, Alejandra | Max-Planck-Institut f. Extraterrestrische Physik, Germany |
| | Kim, Jae-Young | Max-Planck Institut für Radioastronomie (MPIfR), Germany |
| | Kolwa, Sthabile | European Southern Observatory, Germany |
| | Krishnan, Hariharan | National Centre for Radio Astrophysics (NCRA-TIFR), India |
| | Laing, Robert | SKA Organisation, UK |
| | Lee, Chang Won | Korea Astronomy and Space Science Institute, Rep. of Korea |
| | Levrier, François | ENS Paris / Observatoire de Paris, France |
| | Liu, Hanyu Baobab | ESO, Germany |
| 31 | Liuzzo, Elisabetta | IRA-INAF, IT ARC. Italy |
| | Magalhaes, Antonio Mario | IAG - University of Sao Paulo, Brazil |

| | | |
|----|---------------------------|--|
| | Marti-Vidal, Ivan | Onsala Space Observatory, Sweden |
| | Massardi, Marcella | INAF-IRA/Italian ARC node, Italy |
| | Maury, Anaëlle | CEA Astrophysical department, AIM, Paris Saclay University, France |
| | Menard, Francois | Universite Grenoble, France |
| | Miotello, Anna | ESO, Germany |
| | Moellenbrock, George | NRAO, Socorro, USA |
| | Mroczkowski, Anthony | ESO, Germany |
| | Mundell, Carole | University of Bath, UK |
| 41 | Myserlis, Ioannis | Max-Planck-Institut für Radioastronomie, Germany |
| | Nagai, Hiroshi | NAOJ, Japan |
| | Nikiel-Wroczyński, Błażej | Astronomical Observatory, Jagiellonian University, Poland |
| | Orienti, Monica | INAF - IRA Bologna, Italy |
| | Paladino, Rosita | INAF - IRA, Italy |
| | Pattle, Katherine | University of Central Lancashire, UK |
| | Peest, Peter Christian | Universiteit Gent, Belgium |
| | Pelgrims, Vincent | Laboratoire de Physique Subatomique et de Cosmologie, France |
| | Pillai, Thushara | MPIfR, Germany |
| | Pietu, Vincent | IRAM, France |
| 51 | Sabz Ali, Vajihah | Institute for Research in Fundamental Sciences, Iran |
| | Sanna, Alberto | MPIfR, Germany |
| | Siebenmorgen, Ralf | ESO, Germany |
| | Slagter, Reinoud | ASFYON, Netherlands |
| | Soam, Archana | Korea Astronomy & Space Science Institute, South Korea |
| | Testi, Leonardo | ESO, Germany |
| | Tomisaka, Kohji | National Astronomical Observatory Japan, Japan |
| | Valdivia, Valeska | Département d'Astrophysique - AIM/CEA Saclay, France |
| | Wiesemeyer, Helmut | Max Planck Institute for Radio Astronomy, Germany |
| | Zhang, Heshou | DESY, Germany |
| 61 | Zhang, Qizhou | Harvard-Smithsonian CfA, USA |
| | Zwaan, Martin | ESO, Germany |

Certified as a correct and complete list of participants at the meeting.

R. A. Laing

Prof Robert Laing
Garching, 2017 October 27