

## Report from the event supported by RadioNet

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**TITLE** *INTERNATIONAL PULSAR TIMING ARRAY ANNUAL CONFERENCE*

**DATE:** *JUNE 26<sup>TH</sup> – JULY 7<sup>TH</sup>, 2017*

**LOCATION:** *PARIS (SÈVRES), FRANCE*

**MEETING WEBPAGE:** *<http://ipta.phys.wvu.edu/index.html>*

**HOST INSTITUTE:** *PARIS OBSERVATORY*

**RADIONET  
BENEFICIARY / NO:** *TO BE FILLED BY MANAGEMENT*

*accepted on 13.7.2017*

*Pabele Pott*

# Report:

## 1. SCIENTIFIC SUMMARY

The International Pulsar Timing Array collaboration is made of the contributions of three continental consortia: EPTA in Europe, PPTA in Australia and NanoGRAV in North America. Its primary goal is to detect gravitational waves in the Nanohertz regime using radio pulsar timing observations.

This year the annual IPTA conference took place in Sèvres, France. As usual, it has started with a Student Workshop preparing the new generations of scientists to both the technics of pulsar timing and gravitational wave analysis.

The student week was organized mainly in lectures in the morning and practice exercises in data analysis and statistical methods, using the tools provided by the community (Tempo2, TempoNest, PSRCHIVE, PINT). This program was completed by invited seminars with local expert in e.g. Reference Time Scale (G.Petit), Planetary Ephemerides (A.Fienga), General Relativity (A.LeTiec, E.Gourgoulhon), Plasma Physics (J.M.Griessmeier). 25 students from graduate to Post-doc level participated to this school, surrounded by 10 lecturers from the IPTA collaboration.

The Science Meeting followed the week after, gathering 78 participants (19 women) from all over the world. The agenda was organized in coherent sessions, with series of 15 minutes talks and a long discussion session closing the day. The defining moment of the meeting was the open day about multi-messenger gravitational wave astronomy on Wednesday July 5<sup>th</sup>, that gathered invited speakers from connected fields, and covered the last results from LIGO/Virgo, LISA collaboration, CMB polarization B-modes, gravitational antenna MIGA, GRAVITY experiment at VLT, and of courses the Pulsar Timing Array across the world. The other days were devoted to data gathering and radio telescopes updates, to gravitational wave analysis techniques, to the methods for characterizing the various forefronts (intrinsic pulsar noise, interstellar medium imprints, planetary ephemerides systematics etc...) and to the ongoing collaborative projects. The discussions addressed questions such as general organization, publication and communication policy, data homogenization issues between telescopes and backends and prospective plans for the future of the consortium, including the rising weight of South African and Chinese contributions.



*Kuo Liu (MPIfR, Bonn) introducing the topic to a group of 30 students and post-docs on Monday June 26<sup>th</sup>.*

*Li Di, project scientist of FAST, presenting the last news from the newborn giant radio telescope in China on Monday July 3<sup>rd</sup>.*



Radionet supports the European Pulsar Timing Array program since its foundation in 2006. The Transnational Access funding also supports most of the European facilities involved in this PTA world wide program: Effelsberg, GR; Jodrell Bank, UK; Westerbork, NL; Nançay, FR; Sardinia Radio Telescope, IT; Parkes, AU, Green Bank and Arecibo telescopes, US. The European radio telescopes are all allocating an important part of their observing time to the PTA program, providing high precision homogenized pulsar Times of Arrival (TOAs) as well as new millisecond pulsar targets through dedicated search surveys. This annual meeting is a unique showcase for sharing our high quality European timing data, in particular those produced with multi-telescope phased array (LEAP experiment). This is also a unique environment to form our European students to the new algorithms and technics to analyze these data. Furthermore, most of the lecturers for the student week were part of the Radionet institutes, and this participates to their influence on the international scene.

## 2. AGENDA OF THE EVENT

### IPTA 2017 Student Week Schedule

#### **Monday, June 26**

09:00 – 09:10 Welcome/Bienvenue à Paris [Gilles Theureau]  
09:10 – 10:10 [Lecture]: Introduction to pulsar timing [Kuo Liu]  
10:10 - 10:30 Overview of student presentations [Delphine Perrodin]  
10:30 – 11:00 Coffee break / Undergraduate student meeting [Jeffrey Hazboun]  
11:00 – 12:30 [Lecture] Introduction to reference time scales [Gérard Petit, BIPM]  
12:30 – 13:30 Lunch  
13:30 – 15:00 [Lecture] The INPOP planetary ephemeris [Agnès Fienga, OCA, Nice]  
15:00 – 15:30 [Activity] Pulsar timing I: TOA extraction with PSRCHIVE [Kuo Liu, Stefan Osłowski, James McKee]  
15:30 – 16:00 Coffee break  
16:00 - 17:30 [Activity] Pulsar timing I: TOA extraction with PSRCHIVE

#### **Tuesday, June 27**

09:00 -10:30 [Lecture] Post-Keplerian effects in binary systems [Alexandre Le Tiec, LUTH]  
10:30 - 11:00 Coffee break  
11:00 – 11:30 [Lecture + Demo]: Introduction to TEMPO2 [James McKee]  
11:30 – 12:30 [Activity] Pulsar timing II: Familiarization with TEMPO2 [James McKee, Lucas Guillemot, Kuo Liu, Stefan Osłowski]  
12:30 – 14:00 Lunch  
12:30 – 13:30 Women's lunch (CIEP cafeteria)  
14:00 – 14:30 [Activity] Pulsar timing II – TEMPO2  
14:30 – 15:30 [Lecture+Demo] Introduction to PINT [Luo Jing]  
15:30 – 16:00 Coffee break  
16:00 – 17:30 [Activity] Pulsar timing III: Familiarization with PINT [Luo Jing]  
20:30 Babyfoot (foosball) tournament

#### **Wednesday, June 28**

09:00 – 10:00 [Lecture] Introduction to gravitational wave science [Jeffrey Hazboun]  
10:00 – 11:00 [Lecture] Astrophysical sources of GW [Alberto Sesana]  
11:00 – 11:30 Coffee break  
11:30 – 12:30 [Lecture] Detection of GWs with PTAs [Delphine Perrodin]  
12:30 – 14:00 Lunch  
14:00 – 15:00 Sources of noise in PTA datasets; Bayesian methods [Lindley Lentati]  
15:00 – 15:30 [Activity] Pulsar timing noise [Lindley Lentati, Jeffrey Hazboun]



15:30 – 16:00 Coffee break  
16:00 – 17:30 [Activity] Pulsar timing noise

#### **Thursday, June 29**

09:00 – 09:45 [Lecture] Data analysis techniques for GW detection [Antoine Petiteau, Paul Baker]  
09:45 – 10:30 [Lecture] Interstellar medium, dispersion and scattering effects [Jean-Mathias Griessmeier]  
10:30 – 11:00 Coffee break  
11:00 – 12:30 [Lecture] the Galactic central BH and the no hair theorem [Ericourgoulhon, LUTH]  
12:30 – 14:00 Lunch  
14:00 – 15:30 [Activity] Running GW detection pipelines [Paul Baker, Antoine Petiteau]  
15:30 – 16:00 Coffee break  
16:00 – 17:00 [Activity] Running GW detection pipelines  
17:00 – 17:30 Student presentation preparation and Q&A [everyone]

#### **Friday, June 30**

09:00 – 10:00 [Lecture] Pulsar searches, discovery, confirmation and timing [Peter Gentile]  
10:00 – 10:30 Student presentations I  
10:30 – 11:00 Coffee break  
11:00 – 12:00 [Lecture] Developing PSRCHIVE tools [Stefan Oslowski]  
12:00 – 12:30: Student presentations II  
12:30 – 14:00 Lunch  
14:00 – 15:30 Student presentations III  
15:30 – 16:00 Coffee break  
16:00 – 17:00 Career panel

### **IPTA 2017 Science Meeting Program**

#### **Monday**

##### **I. Radio telescopes (09:50 – 12:30) (chair : Ismaël Cognard)**

Gilles Theureau, *Welcome address (10')*

Delphine Perrodin, *Pulsar science at the Sardinia Radio Telescope (15+5')*

Fronefield Crawford, *The Arecibo remote command center network (15+5')*

Renée Spiewak, *Secondary Science with the GBT North Celestial Cap Survey (15+5')*

11:00 – 11:30 coffee break

Xinping Deng, *Observing with a phased array feed at the Parkes Telescope (15+5')*

Li Di, *A Pulsar-Galaxies-MW-FRB Commensal Survey Plan for the Five-hundred-meter Aperture Spherical radio Telescope (15+5')*

Jingbo Wang, *New radio telescope -- QTT 110 meter and Tianma 65 meter radio telescope and Pulsar Timing Array in China (15+5')*

12:30 – 14:20 lunch break

##### **II. Timing data (14:20 - 15:40) (chair : Gregory Desvignes)**

Richard Manchester, *PPTA project (15+5')*

Kuo Liu, *Overview and update on the LEAP (15+5')*

James Mc Kee, *new backend generation EPTA data set (15+5')*

David Nice, *NANOGrav overview* (15+5')

15:40 – 16:10 coffee break

Andrea Lommen, *Precision timing with NICER* (15+5')

Peter Gentile, *Polarization calibration of NANOGrav's Arecibo data set* (15+5')

Discussions (16:50-18:00): (chair : Stefan Osłowski)

*DR2 and future datasets, including new PTA contributions (FAST, GMRT, MeerKAT...)*

*Cyber-i discussions and a demo (R. Ferdman)*

## Tuesday

I. Updates from PTA's analysis groups (09:30-11:40) (chair : Antoine Petiteau)

Steve Taylor, *Update on NANOGrav Data Analysis Methods* (20+5')

Chiara Mingarelli, *EPTA data analysis overview*. (20+5')

Ryan Shannon, *Update on PPTA data analysis*. (20+5')

10:45 – 11:15 coffee break

II. PTA vs ephemeris (11:15-12:15) (chair : Nicolas Caballero)

Stephen Taylor, *Gravitational-wave constraints in the presence of solar-system ephemeris uncertainties*. (15+5')

Joseph Lazio, *Solar System Ephemerides, Pulsar Timing, and Navigation*. (15+5')

Abhinav Jindal, *Constraints on Planet Nine and distant solar system objects using Pulsar Timing* (15+5')

12:15 – 14:20 lunch break

III. Search methods and algorithms (14:20-16:00) (chair : Steve Taylor)

Siyuan Chen, *Implications on Astrophysical model selection from the PPTA upper limit*. (15+5')

Janna Goldstein, *Sky localisation of monochromatic GW sources in pulsar timing array data using the null stream method*. (15+5')

Chiara Mingarelli, *Detection Prospects of Local Continuous Nanohertz Gravitational-Wave Sources with Pulsar Timing Arrays*. (15+5')

Naoyuki Yonemaru, *New detection method for ultra-low frequency gravitational waves with pulsar spin-down rate statistics*. (15+5')

Paul Baker, *Enterprise: a new PTA data analysis suite*. (15+5')

16:00 – 16:30 coffee break

Discussions (16:30-17:30): (chair : Alberto Sesana): Scientific requirements for a detection protocol; Publication and communication policy

## Wednesday [external attendees, invited reviews]

I. Theory (chair : Gilles Theureau)

09:00 Alexandre Le Tiec, *General relativistic dynamics of binary black holes*

09:35 Luc Blanchet, *Gravitational waves and the problem of motion in GR*

10:10 Eric Gourgoulhon, *Black Hole observations and the no-hair theorem*

10:45 – 11:15 coffee break

II. experimentations (chair : Stanislas Babak)



11:15 Matteo Barsuglia, *LIGO and Virgo: status and next steps*

11:45 Antoine Petiteau, *The LISA mission*

12:20 – 14:00 *lunch break*

14:00 Bess Fang, *Low Frequency Gravitational Wave Detection with Ground Based Atom Interferometer Arrays*

14:35 Guillaume Patanchon, *B-mode measurements with Planck and future missions*

15:10 Guy Perrin, *The GRAVITY VLT experiment and the central BH*

15:45 – 16:15 *coffee break*

### III. PTAs : the low frequency end (chair : Andrea Lommen)

16:15 Megan De Cesar, *The Second IPTA Data Release and Considerations for Future Releases*

16:50 Michele Vallisneri, *Current limits from PTAs and current modeling approaches*

17:25 Irina Dvorkin, *Measuring the stochastic gravitational-wave background from stalling massive black-hole binaries with pulsar-timing arrays*

Discussions (18:00-18:45) : multi-messenger information (chair : Andrea Lommen)

19:15 *Cocktail-dinner*

## **Thursday**

### I. Sources of noise (9:30-10:30) (chair : Caterina Tiburzi)

Paul Brook, *Pulse profile variability in the NANOGrav 11-years data set (15+5')*

Aditya Parthasarathy Madapusi, *Profile variability studies for the PPTA pulsars (15+5')*

Michael Lam, *The NANOGrav 9-year Data Set : excess noise in MSP arrival times (15+5')*

10:30 – 11:00 *coffee break*

### II. ISM effects (11:00-12:00) (chair : Lindley Lentati)

Caterina Tiburzi, *The effect of the Solar wind in low-frequency observations of pulsars (15+5')*

Megan Jones, *Analysis of DM variations in the NANOGrav 9-years data set (15+5')*

Stefan Osłowski, *Probing the extremes of ISM with LOFAR (15+5')*

12:00 – 14:00 *lunch break*

### III. Consortium projects (14:00-15:00) (chair : Kuo Liu)

Li Guo, *A pulsar-based time standard with International Pulsar Timing Array (15+5')*

Tim Dolch, *Analyzing Single Pulses in the J1713 24-hr Global Campaign (15+5')*

Nicolas Caballero, *Planetary ephemeris (IPTA project) (15+5')*

### IV. Other projects using PTA data (15:00-15:40) (chair : Kuo Liu)

Jiang Dong, *Build advanced national frequency standard by Pdot of pulsar (15+5')*

Jingbo Wang, *Comparison of pulsar position from timing and Very Long Baseline Astrometry (15+5')*

15:40 – 16:10 *coffee break*

Xiaojin Liu, *Measuring the second derivative of the spin frequency in precise pulsar timing (15+5')*

Golam Shaifullah, *Spectral indices of MSPs (15+5')*

Mallory Roberts, *X-ray luminosity of pulsars with accurate distances (15+5')*

Discussions (17:10-18:00): (chair : Dan Stinebring): New IPTA consortium projects

## Friday

### I. New instrumental/numerical/algorithmic developments (9:30-10:30) (chair : Lucas Guillemot)

Lindley Lentati, Cobra : *Bayesian approach to pulsar searching (15+5')*

Keesi Caballero, *The Centre for Advanced Radio Astronomy (15+5')*

Jing Luo, *PINT a new generation of high precision timing package (15+5')*

10:30 – 11:00 coffee break

Di Li, *A database-based pulsar-pulse search pipeline (15+5')*

Jeffrey Hazboun, *The NANOGrav pulsar signal simulator (15+5')*

### II. The IPTA Diversity Committee (11:40-12:30) (chair : Delphine Perrodin and Chiara Mingarelli)

IPTA Code of Conduct / anti-harassment policy

Development of interactive sessions promoting diversity-related issues

Accessibility of future IPTA meetings

12:30 – 14:20 lunch break

Discussions (14:20-15:20) (chair : Gemma Janssen): PTA observations in the SKA era; Future instrumentation and future analysis tools

## 3. PARTICIPANTS

Among the 78 participants, 39 were from a European Institute, 19 were women. Most of the others came from either North America, Australia or China. We had another regular 6 remote participants following the talks and discussions through a youtube channel (from South Africa and US mainly). The student fraction was about a third of the audience of the second week.



Insert the attendance list (including name, affiliation and country) – signed by the participants or signed by the organisers (in case of heavy burden with collecting all participant signatures).

## 4. RADIONET FINANCIAL CONTRIBUTION

The IPTA Student Workshop is traditionally free of charge for attending students and lecturer, accommodation and daytime expenses being covered by collected grants from various institutions. Radionet contributed (4.0 k€) to this support together with Region Île de France (5.5 k€), CNRS (12.5 k€) and Paris Observatory (4.5 k€). All participants to the Student Week stayed at the Centre International d'Études Pédagogiques (CIEP), which provides hotel rooms, coffee breaks and lunches, as well as seminar and conference rooms with full equipment.

### List of supported participants:

Henryk Haniewicz, UK  
Siyuan Chen, UK  
Julian Donner, GER  
Lorenz Haase, GER  
Ben Gillen, US  
Naoyuki Yonemaru, Jap  
Xiaojin Liu, UK  
Jiang Dong, China  
Jing Luo, US  
Keeisi Caballero, US  
Lin Wang, China & UK  
Brent Shapiro-Albert, US  
Caitlin Witt, US  
Janna Goldstein, UK  
Renée Spiewak, AU  
Paul Baker, US  
Haley Wahl, US  
Lars Künkel, GER  
Antonia Orsini, US  
Megan Jones, US  
Aditya Parthasarathy Madapusi, AU  
Paul Brook, US  
Abhinav Jindal, CA  
Madhuri Gaikwad, GER  
Anika Rowe, US

## 5. PUBLICATIONS

**High-precision timing of 42 millisecond pulsars with the European Pulsar Timing Array.** Desvignes, G. et al 2016, MNRAS 458, 3341

**From spin noise to systematics: stochastic processes in the first International Pulsar Timing Array data release.** Lentati, L. et al 2016, MNRAS 458, 2161

**The International Pulsar Timing Array: First data release.** Verbiest, J., 2016, MNRAS 458, 1267





**Single-Source Gravitational Wave Limits From the J1713+0747 24-hr Global Campaign.** Dolch et al 2016, Journal of Physics: Conference Series, Volume 716, Issue 1, article id. 012014

**The noise properties of 42 millisecond pulsars from the European Pulsar Timing Array and their impact on gravitational-wave searches.** Caballero, N. et al 2016, MNRAS 457, 4421

**European Pulsar Timing Array limits on continuous gravitational waves from individual supermassive black hole binaries.** Babak, S. et al 2016, MNRAS 455, 1665

**European Pulsar Timing Array limits on an isotropic stochastic gravitational-wave background.** Lentati L, et al. MNRAS, 453, 2576 (2015)

**Limits on Anisotropy in the Nanohertz Stochastic Gravitational Wave Background.** Taylor S, et al., PhRvL, 115, 041101 (2015)