Report from event supported by RadioNet

TITLE	*IPTA HACK WEEK 2019*
DATE:	*DECEMBER 9TH-13TH , 2019*
LOCATION:	*MEUDON, FRANCE*
MEETING WEBPAGE:	*https://ipta-hackweek.sciencesconf.org/*
HOST INSTITUTE:	*PARIS OBSERVATORY*
RADIONET BENEFICIARY / NO:	*OBSPARIS / 10*

RadioNet has received funding from the EU's Horizon 2020 research and innovation programme under the grant agreement No 730562

Report:

1 SCIENTIFIC SUMMARY

https://ipta-hackweek.sciencesconf.org/

The International Pulsar Timing Array (IPTA) is a world wide collaboration, made of the contributions of three continental consortia: EPTA in Europe, PPTA in Australia and NanoGRAV in the US. Its primary goal is to detect gravitational waves (GW) in the Nanohertz regime using radio pulsar timing observations. At the European level, the EPTA program gathers scientific teams associated with the five 100-m class radio telescopes of the continent (Jodrell Bank, UK, Westerbork, NL, Effelsberg, Ger, Cagliari, It, Nançay, Fr). Several European groups are also contributing on the gravitational wave analysis and theory, in particular in Birmingham University, MPI für Gravitationsphysik in Postdam, Milano University.

We gathered the main contributors to the IPTA data combination and gravitational wave analysis for an operational workshop, held in Meudon Observatory (France).

1.1 SCIENTIFIC SUMMARY

The IPTA Hack Weeks gave the opportunity to confront new algorithms and state of the art detection strategies. We explored various noise and gravitational wave models, using available combined pulsar timing data coming from the various radio telescopes, while at the same time obtained a leap in the data combination of new millisecond pulsars observed using the last generation of pulsar backends.

1.2 RADIONET RELEVANCE

Pulsar timing observations represent a large fraction of European radio telescope time at all these facilities, with a total amount of more than 3000 hours dedicated per year, since the start of the project in 2006.

The timing of an array of stable millisecond pulsars (PTA) works as a Galactic sensor for gravitational wave direct detection in the frequency regime from Nanohertz to Microhertz. It is complementary to ground based (LIGO-Virgo, Herzt-Kilohertz) and future spatial (eLISA, milliHertz) interferometers. This technique is the unique one probing the emission of the supermassive binary black hole binary population that was formed in the hierarchical large scale structure and galaxy building scenario. Virgo-LIGO observations since 2016 enabled the first direct detections of gravitational wave signals. Even though PTAs have yet only produced upper limits on the nHz background or individual sources gravitational radiation, the recent results start to constrain models of structure formation, the growth of the galaxy central black hole and the migration rate of the black hole binaries formed in mergers towards the gravitational wave emission regime. With improving radio telescopes detectors and data analysis techniques, a detection is expected within the coming 5-10 years with the current generation of

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instruments, while we will have to wait for SKA1 to fully confirm preliminary detections, identify and characterise the sources and their spectrum.

1.3 IMPACT

The Timing data gathered at each telescope are combined at the world wide level to produce successive data releases and new constraints on the gravitational stochastic background and possible single sources. The main targeted population is the super massive binary black hole population, supposed to form in the process of galaxy hierarchical formation and evolution. So far a first IPTA data release (DR1) was published in 2016 by Verbiest et al, the second one (DR2) was published this year (Perera et al 2019). One of the goals of the 2019 Hack Week was to start building the third one (DR3), with a strong and up-to-date contribution from Europe. Another one was to finalise the three on-going publications concerning: 1) a new GW stochastic background limit from IPTA DR2; 2) an analysis for searching GW burst with memory events; 3) an analysis of the GW stochastic background based on the figure of merit of individual pulsars observed at single telescopes.

Our goal in particular was to include in the DR3 some of the data produced in the last eight years by the last generation of European pulsar backends : ASTERIX on Effelsberg, PUMA-II on WSRT, NUPPI-512 on NRT, DFB at Jodrell Bank and Roach-2 system at SRT.

2 AGENDA OF THE EVENT

Monday, 9th

9.30 - 10 AM: Arrival and welcome
10 - 10.30 AM: Presentation of the cut GWB analysis + paper (Paul Baker - remotely)
10.30 - 11 AM: Coffee break
11 - 12.30 PM: Discussion and hacking for the cut GWB paper
12.30 - 2 PM: Lunch
2 - 4 PM: Discussion and hacking for the cut GWB paper
4 - 4.30 PM: Coffee break
4.30 - 5 PM: Presentation of the injection analysis + plans (Nihan Pol - remotely)
5 - 6 PM: Discussion and hacking for the cut GWB paper + injections

Tuesday, 10th

9.30 - 10.30 AM: Summary of the cut GWB analysis + paper discussion + hacking (Daniel Reardon)
10.30 - 11 AM: Coffee break
11 -11.30 AM: Presentation of the lite GWB analysis + paper (Chiara Mingarelli)
11.30 - 12.30 PM: Discussion and hacking for the lite GWB paper
12.30 - 2 PM: Lunch
2 - 4 PM: Discussion and hacking for the lite GWB paper
4 - 4.30 PM: Coffee break
4.30 - 6 PM: Discussion and hacking for the lite GWB paper + injections

Wednesday, 11th

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9.30 - 10.30 AM: Summary of the lite GWB analysis + paper discussion + hacking (Siyuan Chen)
10.30 - 11 AM: Coffee break
11 - 11.30 AM: Presentation of the individual sources search analysis plans (Mikel Falxa)
11.30 - 12.30 PM: Discussion and hacking for the individual sources search
12.30 - 2 PM: Lunch
2 - 4 PM: Discussion and hacking for the individual sources search
4 - 4.30 PM: Coffee break
4.30 - 6 PM: General discussion about other potential IPTA DR2 projects (exotic sources, burst of memory, other non-GW projects, etc.?)

Thursday, 12th

9.30 - 10.30 AM: Plans and discussion about the IPTA DR3 (Ryan Shannon)
10.30 - 11 AM: Coffee break
11 - 12.30 PM: Discussion and experimental hacking on the IPTA DR3
12.30 - 2 PM: Lunch
2 - 4 PM: Discussion and experimental hacking on the IPTA DR3
4 - 4.30 PM: Coffee
4.30 - 6 PM: Discussion and experimental hacking on the IPTA DR3

Friday, 13th

10 - 11 AM: Coffee break
11 - 12.30 PM: Summary of the IPTA DR3 discussion + experimental hacking
12.30 - 2 PM: Lunch
2 - 4 PM: Final discussion about IPTA DR2 GW analyses + future plans
4 - 5 PM: Coffee break and wrap-up

3 PARTICIPANTS

There were 18 participants, including 3 women and 15 men. 3 came from US, 2 from Australia, 2 from Germany, 1 from UK, 7 from France, 2 from Italy, and 1 from The Netherlands

4 were PhD students, 6 were post-docs, 8 were faculty staff members

Five participants attended remotely the afternoon discussion sessions.

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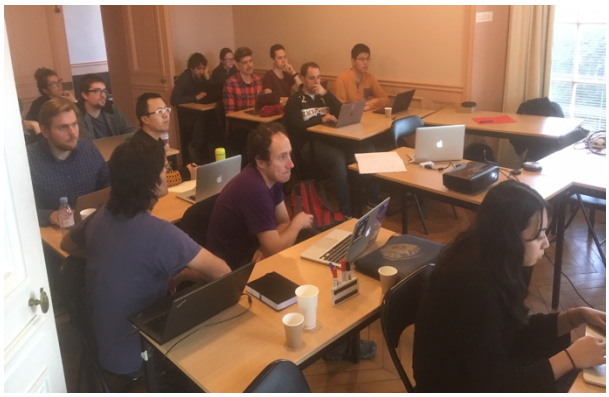

PoI (US)

4 RadioNet financial contribution

The 1400 € funding provided by Radionet was used to cover the whole accommodation, meals and travel for two among the young participants.

5 Publications

In case of future publication, the RadioNet support will be acknowledged by inserting: The project leading to this publication has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730562 [RadioNet]

6 Confirmation

Following the Regulation (EU) 2016/679, RadioNet is allowed to publish this report, incl. participants lists, statistic ´s details, pictures, etc..