Monday, 19 September

11.00 – 11.30	Registration, Coffee
11.30 – 13.00	Welcome, Background on Scintillometry, Chair: Franz Kirsten
	Welcome, Scope of Workshop, Ue-Li Pen (U Toronto, Toronto)
	Scintillometry – the turbulence Picture (tentative), Jean-Pierre Macquart (ICRAR-Curtin, Perth)
	Scintillometry – the current sheet Picture (tentative), Ue-Li Pen (U Toronto)
13.00 – 14.00	Lunch
14.00 – 15.30	MPIfR talks, Chair: Marten van Kerkwijk
	The Large European Array for Pulsars, Kuo Liu (MPIfR, Bonn)
	The Gravitational-Wave Universe seen by Pulsar Timing Arrays, Chiara Mingarelli (MPIfR)
	On the size and orientation of binary orbits (tentative), Paulo Freire (MPIfR)
15.30 – 16.00	Coffee
16.00 – 17.30	**Discussion**: Studying pulsars with scintillometry, Chair: Ue-Li Pen

Tuesday, 20 September

9.00 – 9.30	Coffee
9.30 – 11.00	Resolving scattering screens with VLBI, Chair: Jean-Pierre Macquart
	Cosmic Prisms in Interferometry, Pulsar Timing and Scintillation Arcs, Carl Gwinn and the RadioAstron Pulsar Team
	Investigaton of scattering material in the direction to PSR B0525+21 with space-ground interferometry, Tania Smirnova (ASC LPI RAS, Moscow)
	The scattering Screen of B1957+20 as seen with global VLBI (tentative), Ue-Li Pen (U Toronto, Toronto)
11.00 – 11.30	Coffee
11.30 – 13.00	Giant pulse studies: B1957+ The Crab, Chair: Rene Breton
	Descattering Giant Pulses of B1957 (tentative), Marten van Kerkwijk (U Toronto)
	Localizing the emission of the Crab's giant pulses, Robert Main (U Toronto)
	Pulsar observations with the GMRT (tentative), Viswesh Marthi (NCRA, Pune)

13.00 – 14.00	Lunch
14.00 – 15.30	VLBI on Crab giant pulses, Chair: Dana Simard
	VLBI at low frequencies – first fringes between the MWA and the GMRT, Franz Kirsten (ICRAR-Curtin)
	Probing the complicated scattering geometry of the Crab pulsar through VLBI, Robert Main (U Toronto)
	Radioastron Observations of Giant Pulses from the Crab Pulsar, Alexey Rudnitskiy (ASC LPI RAS, Moscow)
15.30 – 16.00	Coffee
16.00 – 17.30	**Discussions**, Resolving scattering screens using giant pulses and VLBI, Chair: Marten van Kerkwijk

Wednesday, 21 September

9.00 – 9.30	Coffee
9.30 – 11.00	Lensing, Chair: Ue-Li Pen
	Studying the ISM on AU scales through the secondary spectra of scintillating pulsars, Dana Simard (U Toronto)
	More lensing formalism, (tentative) Daniel Baker (U Toronto)
	Time domain scattering (tentative), Aris Karastergiou (U Oxford, Oxford)
11.00 – 11.30	Coffee
11.30 – 12.30	FRBs & The slowly changing ISM, Chair: I-Sheng Yang
	FRB number counts, (tentative) Jean-Pierre Macquart (ICRAR-Curtin, Perth)
	Scintillations and Selection Effects on Fast Radio Bursts, Jim Cordes (Cornell, Ithaca)
	LOFAR studies of the Ionised ISM with Pulsar Observations, Joris Verbriest (U Bielefeld, Bielefeld)
12.30 – 14.00	Lunch
14.00 – 15.30	**Discussion**: Studying the ISM with scintillation, Chair: Jean-Pierre Macquart
15.30 – 16.00	Coffee
16.00 – 17.30	**Discussion**, Current projects and challenges
19.00 – 22.00	**Dinner at Boennsch**

Thursday, 22 September

9.00 – 9.30	Coffee
9.30 – 11.00	Canadian VLBI capabilities, Chair: Robert Main
	400-800MHz VLBI in Canada: the ARO 46m, DRAO 26m Galt, and the 40m CHIME Pathfinder & 100m CHIME Telescope, Keith Vanderlinde (U Toronto)
	VLBI between Arecibo and ARO, (tentative) I-Sheng Yang (U Toronto)
11.00 – 11.30	Coffee
11.30 – 13.00	The Magnetar at the Galactic Centre – 1745-2900, Chair: Daniel Baker
	Latest results on 1745-2900 (tentative), Ralph Eatough (MPIfR)
	Probing interstellar scattering towards the Galactic centre with pulsar VLBI, Olaf Wucknitz (MPIfR)
	Observing 1745-2900 with Black Hole cam, (tentative), Michael Kramer (MPIfR)
13.00 – 14.00	Lunch
14.00 – 15.30	**Discussion**: What is required to facilitate regular low frequency VLBI, Chair: Franz Kirsten
15.30 – 16.00	Coffee
16.00 – 17.30	**Discussion**, Current projects and challenges, continued

Friday, 23 September

9.00 – 9.30	Coffee
9.30 – 13.00	Tour to Effelsberg
13.00 – 14.00	Lunch
~14.30	Return to MPIfR

Book of abstracts

The Large European Array for Pulsars

Kuo Liu (MPIfR)

The Large European Array for Pulsars project establishes a novel infrastructure to harvest the collective power of the biggest radio telescopes in Europe. By coherently combing the five 100-m class radio telescopes in Europe, LEAP forms an equivalently 194-m tied-array telescope, reaching the sensitivity level of the SKA1-mid. LEAP is mainly used to improve pulsar timing precision for the purpose of gravitational wave detection, while the data product can also be useful for other pulsar science projects. In this talk, I will present a detailed description of the LEAP setup, including hardware, observing scheme, software pipeline, data logistics, etc. I will also show scientific output from the project, including the efficacy in improving pulsar timing precision and results from other pulsar science projects with LEAP data. Finally, I will briefly discuss how the LEAP infrastructure, including the available datasets, can be used for scintillometry purpose.

The Gravitational-Wave Universe seen by Pulsar Timing Arrays

Chiara Mingarelli (MPIfR)

Galaxy mergers are a standard aspect of galaxy formation and evolution, and most (likely all) large galaxies contain supermassive black holes. As part of the merging process, the supermassive black holes should inspiral together and eventually merge, generating a background of gravitational radiation in the nanohertz to microhertz regime. Processes in the early Universe such as relic gravitational waves and cosmic strings may also generate gravitational radiation in the same frequency band. An array of precisely timed pulsars spread across the sky can form a galactic-scale gravitational wave detector in the nanohertz band. I describe the current efforts to develop and extend the pulsar timing array concept, together with recent limits which have emerged from European and international efforts to constrain astrophysical phenomena at the heart of supermassive black hole mergers.

Cosmic Prisms in Interferometry, Pulsar Timing and Scintillation Arcs

Carl Gwinn and the RadioAstron Pulsar Team

The Spektr-R telescope of the RadioAstron mission, observing in concert with Earth antennas, has detected "cosmic prisms" along the lines of sight to some nearby pulsars. Cosmic prisms are large-scale transverse gradients of plasma density. They produce a variety of refractive and dispersive effects. In particular, they can disperse weak scintillation to produce modulation index less than 100% (expected only for weak scintillation) in combination with scintillation bandwidth much less than observing frequency (expected only for strong scintillation). Observation of correlation of the scintillation patterns on baselines of 100,000 km and longer demonstrates their effects.

For pulsar timing, cosmic prisms produce a rich variety of dispersive and timing effects, in addition to the well-known monotonic variation of dispersion measure. Prisms that vary from perfect linearity can produce variations of pulse arrival time with frequency, complicating inference of the dispersion measure. Refraction of a few lines of sight by arrays of cosmic prisms, between source and observer, produces scintillation arcs in the secondary spectrum. We discuss the optics and observable properties of these cosmic plasma structures.

Investigaton of scattering material in the direction to PSR B0525+21 with space-ground interferometry

T.V. Smirnova, V.I. Shishov, A.S. Andrianov, C. Gwinn, M.V. Popov

We carried out observations of PSR B0525+21 at 1668 MHz to study the distribution of scattering material in the direction to pulsar. We used Green Bank, Arecibo and RadioAstron telescopes. The projection of base was 233600 km for space-ground interferometer. We had shown that scintillation are strong and spectrum of inhomogeneities is close to Kolmogorov one with the power-law index n = 3.74. We measured the scattering

angle in the direction to pulsar: $\Theta_{\rm scat} = 28 \pm 2\ \mu$as. The plasma located at the distance 0.1z from the pulsar is responsible for scattering of emission, where z is the distance from pulsar to observer. With assumed distance z = 1.6 kpc the screen is located at the distance 160 pc from the pulsar.

B1957 scattering screen (tentative)

Ue-Li Pen (U of Toronto)

No abstarct yet.

B1957 Giant Pulse Studies (tentative)

Marten van Kerkwijk (U of Toronto)

No abstarct yet.

Localizing the emission of the Crab's giant pulses

Robert Main, (U of T, CITA)

The crab pulsar has a striking radio profile, with two pulse components comprised of giant pulses - randomly occuring pulses which extend to extraordinary energies. In addition, the Crab pulsar is a unique scattering system, where the majority of scattering is induced by its surrounding nebula. The scattering tail has extraordinary sensitivity to differences in the Crab's emission, essentially putting the pulsar under a microscope. I will detail our radio observations of the Crab across 150-1650MHz, and our efforts to use the scattering information to localize the emission locations of giant pulses. I will describe a method of coherently de-convolving scattering tails to quantify differences in the scattering's impulse response function, and describe what has and has not worked so far.

Pulsar observations with the GMRT

Viswesh Marthi, NCRA

No abstract yet.

VLBI at low frequencies – first fringes between the MWA and the GMRT

Franz Kirsten (ICRAR-Curtin, Perth)

No abstract yet.

Probing the complicated scattering geometry of the Crab pulsar through VLBI

Robert Main, (U of T, CITA)

The Crab pulsar is a complicated scattering system, requiring at least two screens to agree with the VLBI and scintillation measurements to date. The temporal scattering is believed to be associated with the Crab Nebula itself, which the spatial extent measured with low frequency VLBI is consistent with scattering much further in the ISM. I will describe the distinct, predictable effects that multiple scattering screen will have on VLBI visibilities. I will then describe our Crab VLBI measurements between Algonquin Radio Observatory (ARO) and the Dominion Radio Astronomical Observatory (DRAO) at 400-800 MHz. The impulsive nature of the Crab's giant pulses allows us to study the visibilities as a function of scattering time delay in addition to frequency, and we believe we are observing the transition to the full system being resolved. I will try to put this into context of the existing VLBI measurements of the Crab, to form a consistent picture.

Radioastron Observations of Giant Pulses from the Crab Pulsar

Alexey Rudnitskiy (ASC LPI RAS)

Abstract: We present the results of multi-epoch studies of instantaneous visibilities of giant pulses from the Crab pulsar obtained with the Radioastron Space-VLBI observations. These observations revealed new effects and properties of interstellar plasma scattering radio emission of Crab pulsar. High angular resolution of Radioastron Space-VLBI allowed to resolve the substructure in the scattering disk. The scattering parameters were meausred: diameter of scattering disk, scattering time and distance to the effective scattering screen. According to the analysis of phase structure function an unusual behavior of phase variations was revealed depending on the baseline projection. Additionaly, analysis of visibilities revealed the ultra sort time sub-components in time structure of individual giant pulses at 18 cm wavelength.

Studying the ISM on AU scales through the secondary spectra of scintillating pulsars

Dana Simard (U of Toronto)

The secondary spectra, or the power spectra of the dynamic spectra, of many pulsars contain structure consistent with the interference of scattered images of the pulsar aligned and stationary on the sky. This may mean that the scintillation is predictable and can be accounted for and removed from pulsar observations, and has lead to the field of pulsar scintillometry. However, the mechanism by which these tiny structures, less than an AU across, are generated is still debated, with turbulence as well as folded current sheets being contenders (among others). In this talk, I will first review the information embedded in the secondary spectrum and what this can tell us about these tiny structures. I will then go on to discuss how geometric modelling can be used to make testable predictions of the secondary spectra in the case of a particular mechanism - lensing from folds in current sheets.

Scintillations and Selection Effects on Fast Radio Bursts

Jim Cordes (Cornell)

I will discuss the interplay of extragalactic and Galactic scattering in producing intensity scintillations of FRBs. The presence or absence of Galactic scintillations allows constraints to be made on the location of the scattering plasma relative to an FRB source as well as allowing limits to be placed on the intrinsic source size. Galactic scintillations can be quenched by both bandwidth averaging and by extragalactic scattering, so the modulation amplitude of scintillations is strongly dependent on direction as well as on observing frequency. I will discuss the role of Galactic ISS in the detection statistics of FRBs in large-scale surveys along with their role in redetections.

Probing interstellar scattering towards the Galactic centre with pulsar VLBI

Olaf Wucknitz (MPIfR)

No abstract yet.

400-800MHz VLBI in Canada: the ARO 46m, DRAO 26m Galt, and the 40m CHIME Pathfinder & 100m CHIME Telescope

Keith Vanderlinde (UToronto)

The Canadian Hydrogen Intensity Mapping Experiement (CHIME) is a new, massively redundant, 400-800MHz drift-scan interferometer nearing completion in western Canada. CHIME's core pipeline does not allow for extended voltage capture, but an extension forms tied-array beams and distributes them as VDIF packets via 10GbE ethernet, which can then be captured on commercial hardware. Building on the technologies developed for CHIME and tested on its reduced-scale Pathfinder, we have deployed and operated full receiver chains to the 46m Algonquin telescope in eastern Canada, and to the 26m Galt telescope co-located with CHIME.

Together, these 4 telescopes allow on-demand wideband VLBI recording at sub-GHz frequencies, ideally suited to pulsar scintillation measurements. I will discuss these new instruments, from analog frontends through recording backends.

LOFAR studies of the Ionised ISM with Pulsar Observations

Joris Verbriest, Caterina Tiburzi (Uni Bielefeld)

No abstract yet.