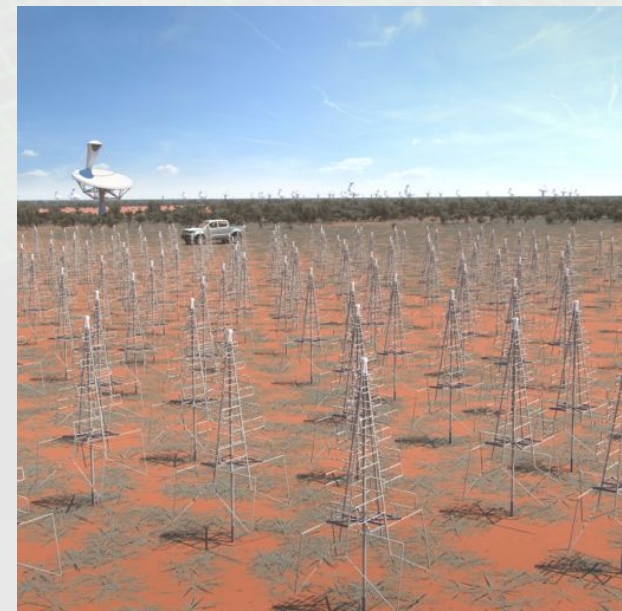
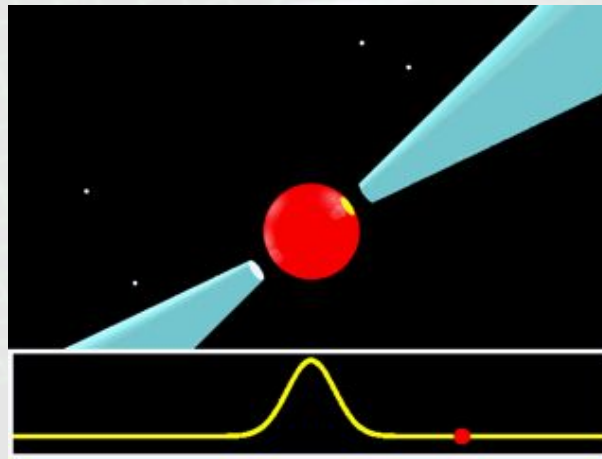


# Pulsar science with the SKA

Gemma Janssen





*Emission physics*

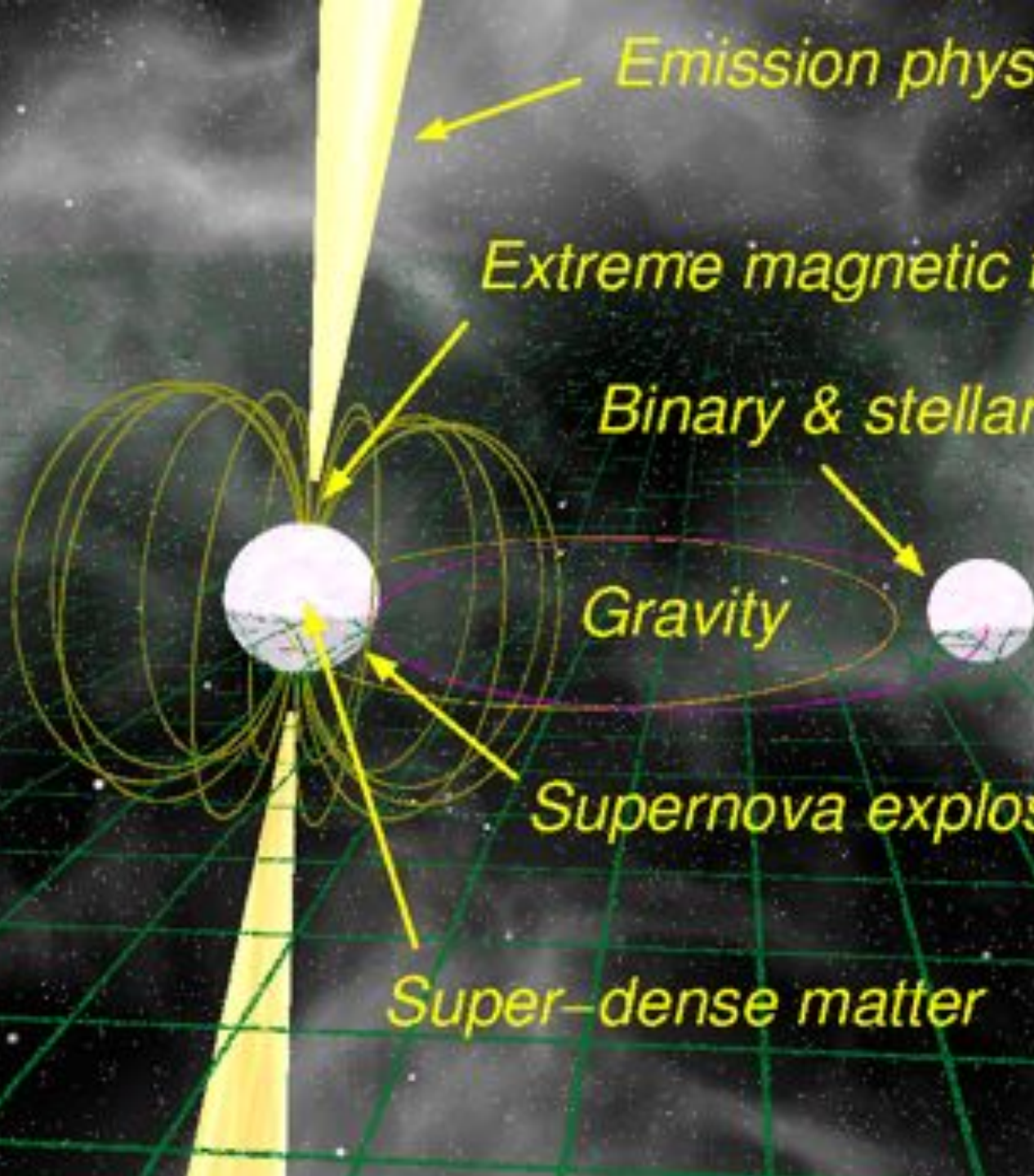
*Extreme magnetic fields*

*Binary & stellar evolution*

*Gravity*

*Supernova explosions*

*Super-dense matter*



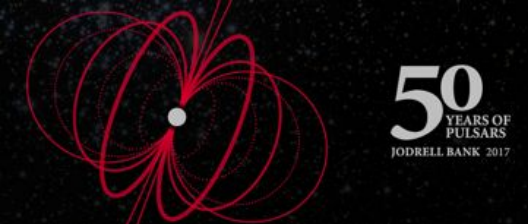
## Pulsar key science goals

Understanding gravity and fundamental interactions  
using pulsars and black holes

From Stockholm 2015 KSP workshop: searching and timing pulsars

1. Triple the currently known pulsar population
2. Find highly relativistic systems and improve tests of gravity in the strong field regime by at least one order of magnitude
3. Finding at least one pulsar/black hole binary and inform quantum gravity
4. Detect gravitational waves at nano-Hertz frequencies
5. Improve the mass-radius relation (NS equation of state) by more than an order of magnitude





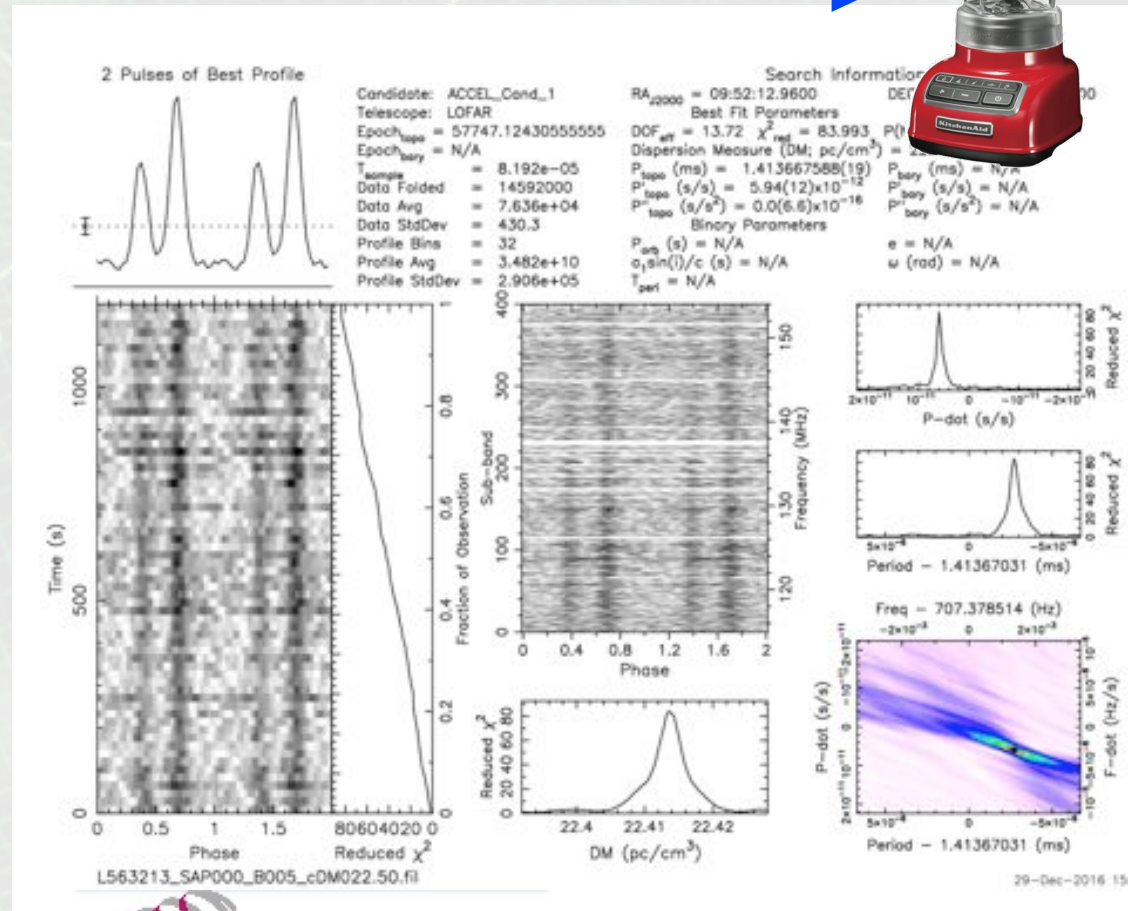
## Pulsar Astrophysics: The Next Fifty Years

IAU Symposium 337 - 4th-8th September 2017 - Jodrell Bank Observatory, University of Manchester

# Pulsar science highlights

## Goal 1: Triple the pulsar population and find exotic systems

- Very fast MSP found with LOFAR: 707 Hz
- New relativistic double neutron binaries found
- 80+ MSPs from Fermi targeted searches
- 84 pulsars from LOTAAS
- First pulsars found with FAST

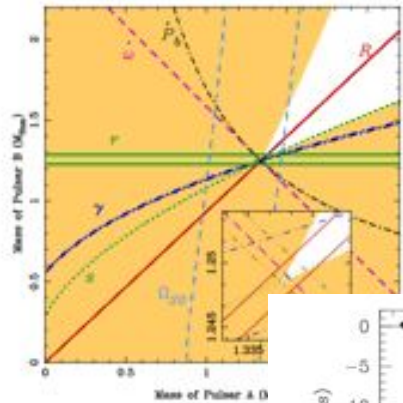


LOFAR



# Pulsar science highlights

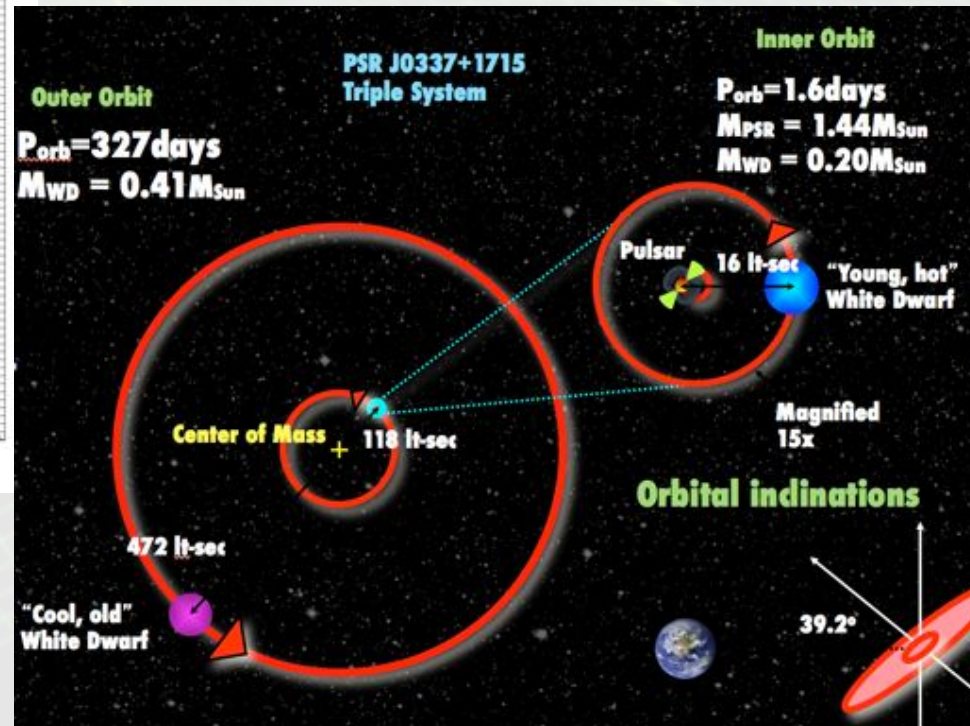
## Goal 2, 5: Tests of gravity and mass measurements



Double Pulsar J0737-3039A/B;  
Kramer et al. in prep



PSR B1913+16;  
Weisberg & Huang 2016, ApJ 829, 55



# Pulsar science highlights

## Goal 4: Detecting low-frequency gravitational waves (IPTA)

- Limits published in international IPTA framework
- Progress on theoretical expectations of GW levels from SMBHBs
- New methods in development to measure and mitigate IISM
- Improvements in understanding systematics

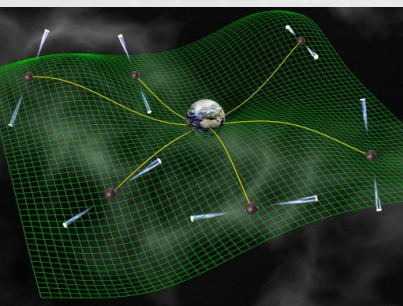
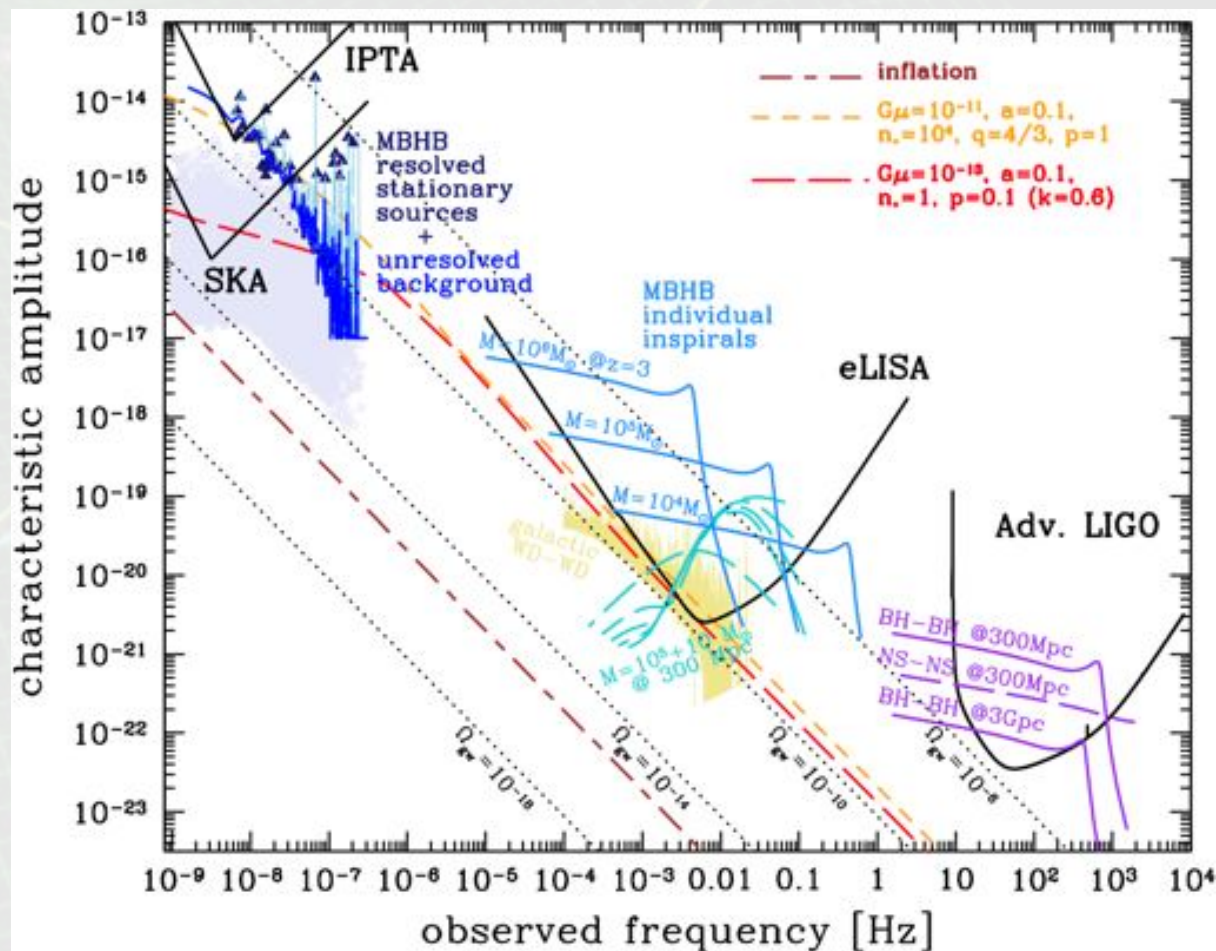


Figure: Champion



## Plans for precursor: MeerKAT



© SKA South Africa

### MeerTIME: KSP on pulsar timing

- Involving AUS, SA, NZ, IT, NL, UK, DE, FR, US, CA institutions
- Management, governance, practicalities very similar to SKA1 planning
- Key Science for MeerTime:
  - Relativistic binaries; tests of GR
  - MSP timing; GW detection
  - Globular Cluster timing
  - 1000 PSR array







## Precursor/Pathfinders: PSR Building experience

### Techniques:

Multibeaming: LOFAR, ARTS, MeerKAT

Coherent dedispersion: LOFAR

Fast-folding (searching): LOFAR, MeerKAT

### Receivers

Next-generation receivers (PAF, UBB): ARTS, MeerKAT, existing single-dish telescopes

Observational (1000 PSR array): CHIME, MeerKAT

### Instrumentation

Pulsar community is designing and building custom hardware (searching/timing) for precursors/SKA1 central signal processors

SKA PSS/PST (Pulsar Search and Timing Systems CDRs successful Jan 2018)



## Evolving Science Working Group into KSP

Q: How will the SWG evolve into a KSP?

A: Discussions started in Stockholm; single KSP with different science packages

A: Likely to follow practical experience of MeerTIME/IPTA

Q: When can the KSP get started?

A: in the building/commissioning phase

- > pulsar astronomers known to be early to new telescopes

- > helping in finding and resolving problems

- > early science can be done with intermediate array (i.e. start PTA obs)

Q: Is an intermediate array release sufficient?

A: Yes, for testing and commissioning

A: BUT the full array (Baseline Design) is **essential** to achieve the KSP science goals





## Potential Issues/concerns/roadblocks

- Pulsar community is putting major effort in pathfinders and precursors AND expecting great science from those.  
Risk for SKA timeline to be too distant; lose interest
- SKAO long timeline between science commissioning, verification and start of KSP requires interactive approach with SWG
- Problem solving in early stages of roll-out can be helped by early pulsar science possibilities
- Pulsar KSP needs full Baseline Design to reach transitional science goals, i.e. no further cuts in beams/processing/bandwidth/sensitivity
- Communication between SKAO and SWGs