

Key Project 5: COSMOS

From the OzGrav-2 proposal, the overarching goal is to:

“Determine fundamental properties of the Universe”

Three themes of the KP5 program:

The Hubble
tension and local
cosmography

Exploring
astrophysics with
gravitational
wave sources

Cosmology with
Fast Radio Bursts

Note: Detection / optical follow-up co-ordination would be in KP2? In KP5 we would focus on cosmological/astrophysical analysis?

Hubble tension and standard sirens

Topics:

- Improving **bright sirens** (peculiar velocity, inclination angle, etc.)
- **Dark sirens** through cross-correlation with large-scale structure
- End-to-end **Bayesian pipeline** for H_0
- **Cosmological simulations** to test the methodology

Tasks:

- Develop H_0 forecasting code and follow-up strategy design
- Test peculiar velocity field reconstruction and error propagation
- Design overall Bayesian H_0 pipeline for bright sirens, propagating errors
- Design overall Bayesian H_0 pipeline for dark sirens, propagating errors
- Optimize observing strategy for wide-field spectroscopic follow-up
- Populate N-body simulation with mock standard siren population
- Use N-body simulation to test Bayesian pipelines for bright and dark sirens
- Apply model-fitting code to bright sirens detected with VLBI

Exploring astrophysics with GW sources

Topics:

- **Isolated binary** evolution modelling
- **Dynamical formation** modelling
- Detailed models of **relevant key phases** in binary evolution
- Models of **complementary observations**
- Connection to **star formation history** and cosmology
- **Population-level inference** on GW sources

Tasks:

- Develop population synthesis models of isolated binary evolution
- Develop models of compact object binary formation through dynamical interactions
- Carry out detailed physics modelling to support the above tasks
- Create detailed models of relevant complementary observations
- Convolve population synthesis models with metallicity-specific star formation history
- Use forward models to carry out astrophysical inference on populations of detections

Cosmology with Fast Radio Bursts

Topics:

- Development of **improved Hubble constant** with FRBs
- Cross-correlations of FRBs with **large-scale structure**
- **Cosmological simulations** to test the methodology

Tasks:

- Continue to obtain FRB localisations through existing pipelines / instruments
- Develop Bayesian pipeline that incorporates host galaxy contributions, large scale structure contributions, and FRB spectro-temporal characteristics
- Use N-body simulation to test Bayesian pipeline

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Questions:

- How should these different topics be weighted, given the latest “vibes” on standard siren discoveries, FRBs, etc.?
- What are the key scientific achievements we should plan for during the first half of OzGrav-2? By the end of the Centre?
- What resources can we bring to bear? (see next slide)
- How best to co-ordinate between the different groups? Associated DP projects? Research programs of the AIs?

Resources

35 postdoc years are written against KP5 (*indicates early hire*)

Node	Topic	CI contact	Postdoc yrs	Theme
Swinburne	Binary evolution / N-body	Hurley	5.6	ASTRO
Swinburne	Radio interferometry / VLBI	Deller	1.4	HUBBLE, FRB
Swinburne	Peculiar velocities and LSS	Blake	4.2	HUBBLE
Swinburne	Bayesian pipeline for FRB analysis	Shannon	3.0	FRB
UQ	Peculiar velocities and LSS	Davis	5.6	HUBBLE
Sydney	Host galaxies + stellar populations + radio transients	Sadler	3.5	ASTRO
Monash	Theory (cosmology/population modelling)	Mandel	3.5	ASTRO
Monash	GW detection (cosmology/population modelling)	Mandel	3.5	ASTRO
Melbourne	EM follow-up and high energy	Auchettl	3.5	ASTRO