Synthetic Telescopes

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The Virtual Observatory

An ambitious program to bring the wealth of all observational data to all astronomers.
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Automatic requests to telescopes.
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What role can theoretical astrophysics play?
Theory VO
Theory VO

- Making theoretical models available to all
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- More than a data and software repository
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- More than a data and software repository
- Provide analysis and visualization tools
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- Making theoretical models available to all
- More than a data and software repository
- Provide analysis and visualization tools
- The ability to make mock observations of theoretical models
Mock Observations

What could you do with synthetic datasets?
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Traditional Astronomy:
The sky is observed, data is reduced and some quantity is measured.
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A process is modeled and some quantity (not always observable) is published.
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A process is modeled and some quantity (not always observable) is published.

How do you effectively make comparisons?
The Inversion Problem

Determination of physical parameters from noisy data;
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- Computationally intensive
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Small amounts of noise make it impossible to distinguish between radically different models.
Forward Modelling

Here, a theoretical model for an emission process is folded through the response function.
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Comparison can then be made in the observational domain.
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Comparison can then be made in the observational domain.

Simple example:

Model data $+$ Convolution : Real data
Real data $+$ Deconvolution : Model data
Real & Fake
Real & Fake
A Synthetic Telescope

If I wished to purchase an amateur telescope, how would I choose what I want?
A Synthetic Telescope

If I wished to purchase an amateur telescope, how would I choose what I want?

A synthetic telescope
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A synthetic telescope

How do we build a synthetic telescope for professional astronomical research?

Thanks to Vince McIntyre
A Real Telescope

The complexity of real observations;
A Real Telescope

The complexity of real observations;

- Different technology (& language!) for different wavelengths
A Real Telescope

The complexity of real observations;

- Different technology (& language!) for different wavelengths
- Photometry, spectroscopy & polarization
A Real Telescope

The complexity of real observations;

- Different technology (and language!) for different wavelengths
- Photometry, spectroscopy & polarization
- Complexity of instrumentation
A Real Telescope

The complexity of real observations:

- Different technology (& language!) for different wavelengths
- Photometry, spectroscopy & polarization
- Complexity of instrumentation
- Variety of reduction techniques
A Real Telescope

The complexity of real observations;

- Different technology (& language!) for different wavelengths
- Photometry, spectroscopy & polarization
- Complexity of instrumentation
- Variety of reduction techniques
- Different interpretations of the same datasets
A Synthetic Telescope

A simplistic view of observational astronomy;
A Synthetic Telescope

A simplistic view of observational astronomy;

“It’s just collecting and sorting of photons, isn’t it?”
A Synthetic Telescope

A simplistic view of observational astronomy;

“It’s just collecting and sorting of photons, isn’t it?”

While being simplistic, it may be a starting point for building synthetic versions of real telescopes & instrumentation.
Further Complications

Most telescopes provide signal-to-noise calculators that produce a *zeroth order* synthetic observation.
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Realistic mock observations, however, need to consider a number of additional issues.
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- Seeing functions are never Gaussian.
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- Response is rarely linear
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Realistic mock observations, however, need to consider a number of additional issues:

- Seeing functions are never Gaussian
- Response is rarely linear
- Noise is never Poisson-like (Poissonic?)
A real ROSAT image
Simulation Complexity

Theoretical astrophysics; a range of activities.
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Theoretical astrophysics; a range of activities.

● ‘Paper & Pen’ theorists
Simulation Complexity

Theoretical astrophysics; a range of activities.

- ‘Paper & Pen’ theorists
- Numerical analysis
Simulation Complexity

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- Numerical & semi-analytic simulations
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Theoretical astrophysics; a range of activities.

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There is no *defined* standard for accommodating theoretical results.
VO Compliance

Some standard is required for the inclusion of theoretical models within the VO.
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This standard should incorporate the information required to produce synthetic observations.
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‘Physical interface’ which turns the models into an emitted spectral signature.
A tool for the comparison of data and models
• A tool for the comparison of data and models
• Also decide what telescope is best for a particular observation
What would future telescopes see?

A range of telescopes will be coming on-line, including James Webb/NGST, LOFAR + SKA, Eddington etc
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A common question is; Just what will these telescopes see?
SKA view of the sky

By Willis (DRAO); 1arcmin to 0.1μJy at 1.4GHz in 9hrs
Why would you want to?

Synthetic observations: complex & time consuming
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- Theoretical results will be available to the wider community and in a more versatile form.
- Powerful interface between observational and theoretical astronomy.
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Synthetic observations: complex & time consuming

- Theoretical results will be available to the wider community and in a more versatile form.
- Powerful interface between observational and theoretical astronomy.
- Faces same problem as overall VO program: who pays for the good of the community?
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Interest from both observers and theorists ($VC^3$, Victoria 2000)
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Faces different problems to the "observational VO" program.
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Great opportunity for Australian astronomy to get involved (ARC?).