Astrostatistics: Complex Models and Complex Questions

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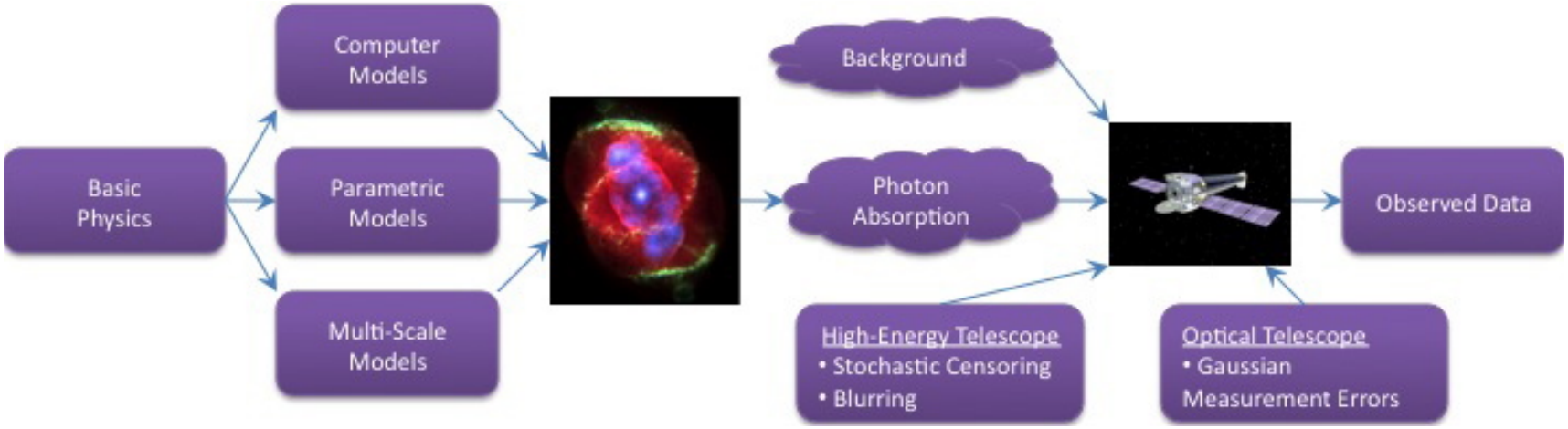
Physics-Based Generative Models



- Aim to formulate models in terms of specific questions of scientific interest.
- Must account for complexities of data generaration.
- Embed complex physics-based models into multi-level statistical models.

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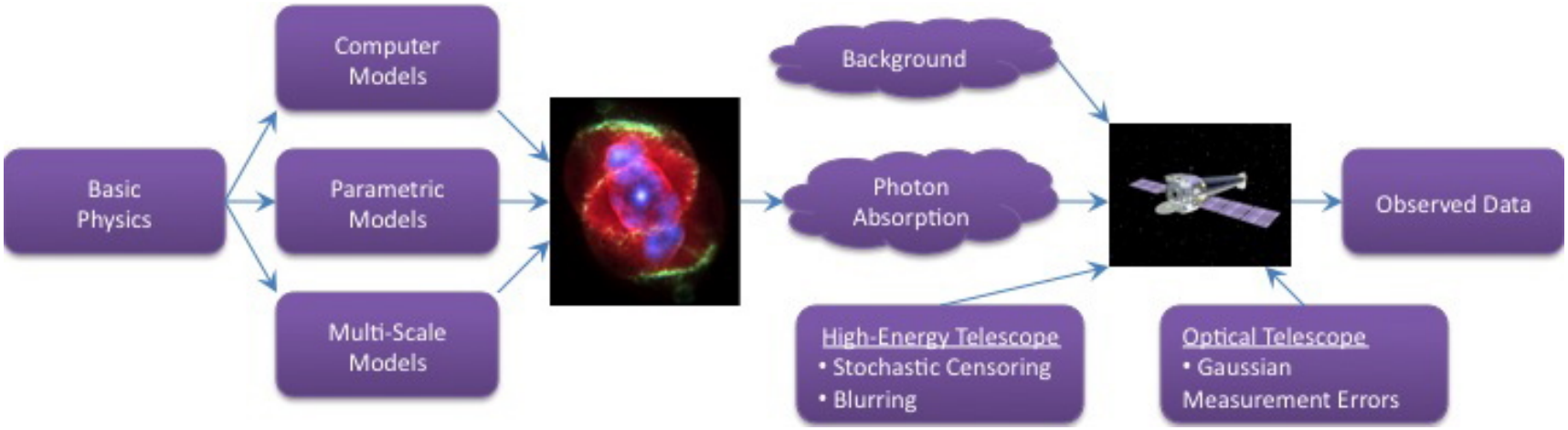
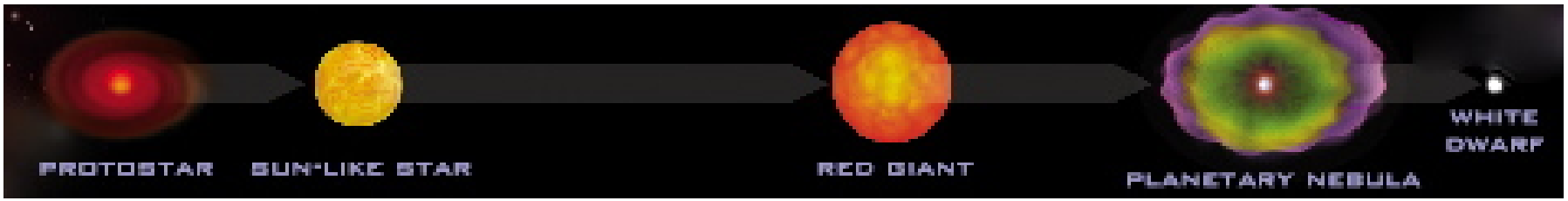
Physics-Based Generative Models



- State of the art data enable us to fit the resulting complex model.
- This require sophisticated computational techniques.

Stellar Evolution



- Sophisticated computationally-expensive physics-based computer models predict the magnitudes of a star given its age, composition, initial mass, distance, and absorption.
- Data are contaminated & include unresolved star systems.
- Misspecification of computer model complicates analysis.
- Highly non-linear correlations and multiple modes in a large dimensional parameter space pose significant computational challenges.

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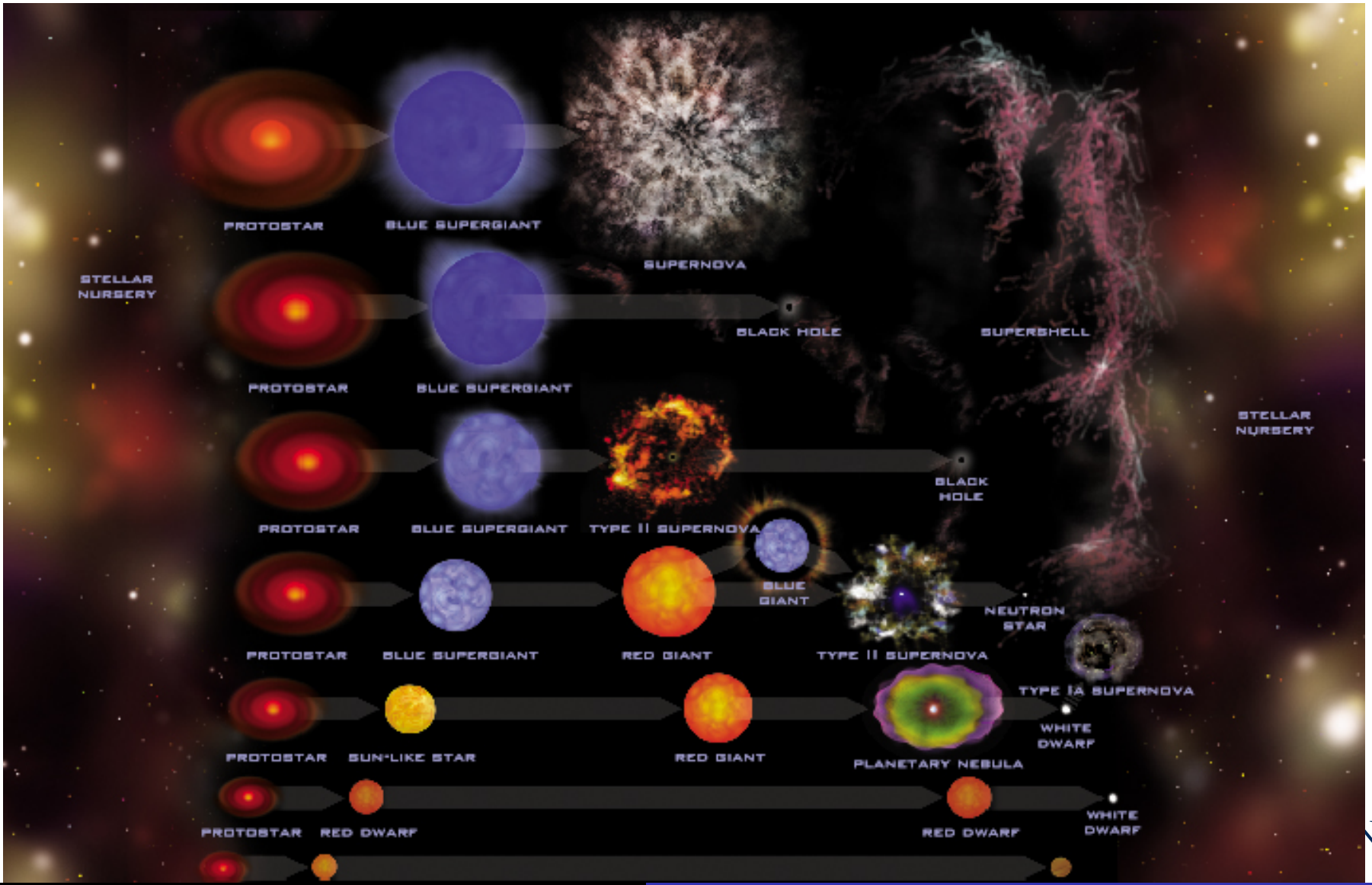
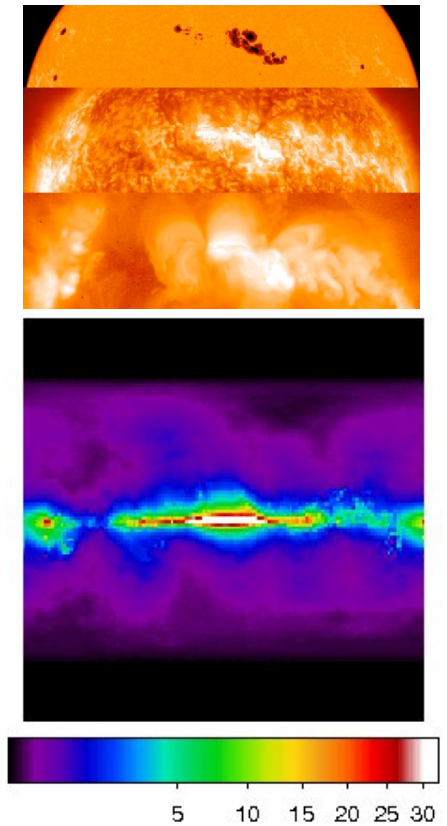
Stellar Evolution



Computer Models and External Information

Multi-level statistical models aim to directly model physical processes that generate observed data:

- Detailed quantum mechanical computations of the expected spectrum of a particular ion at a particular temperature,
- Measurements of the geometry, composition, and spectra of interstellar gas and its interaction with high-energy particles and low-energy light, or
- Measurement errors in high-dimensional instrument calibration.



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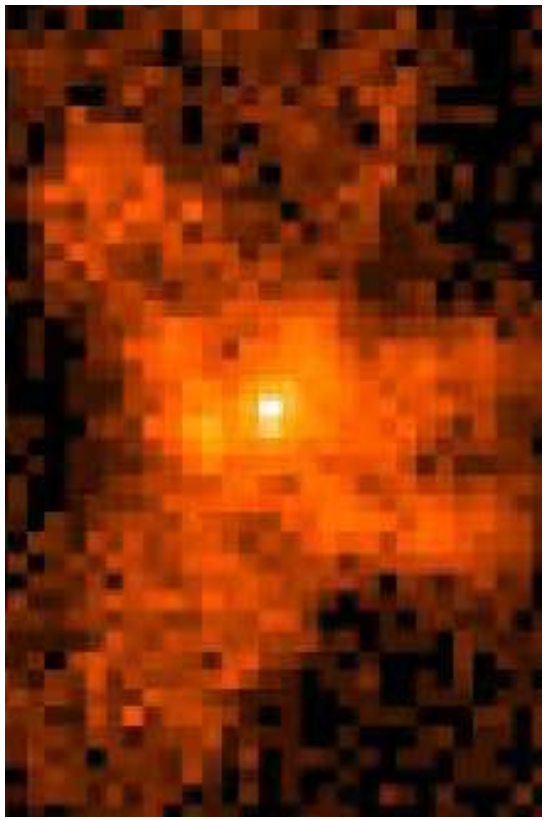
Representing High Dimensional Uncertainty

Representing and/or summarizing high-dimensional uncertainty in complex physics-based models poses real challenges:

- Is a perceived structure in an image real?
- How can we quantify its statistical significance?
- Calibration quantities and quantum mechanical measurements are recorded with error, but correlations are unknown.



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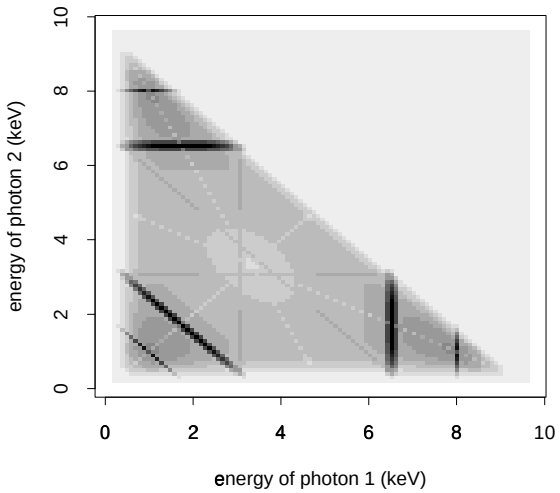
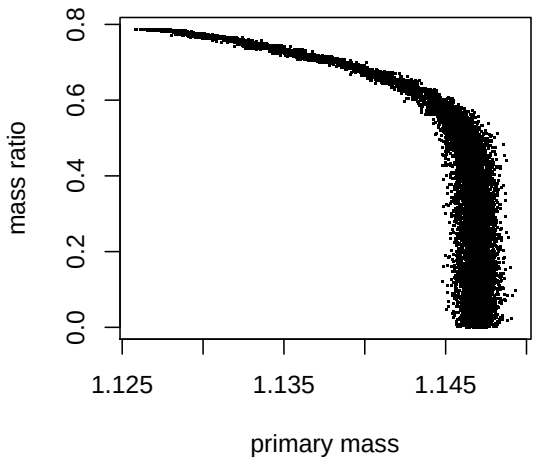
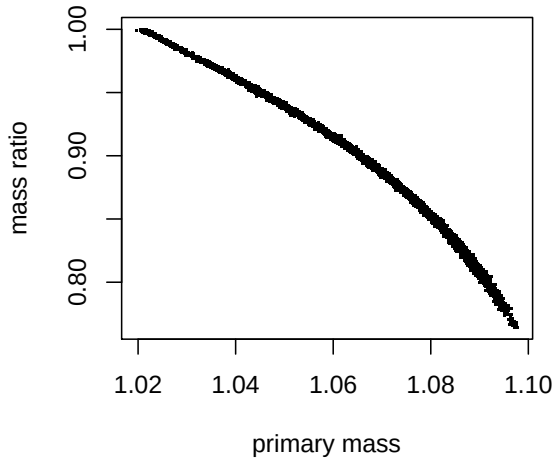
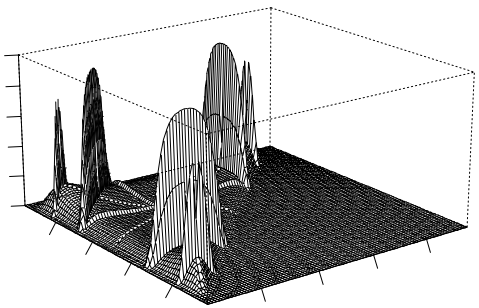
Complex Likelihoods and Posterior Distributions









Difficult to explore, especially in high dimensions.

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The End

THANK YOU!

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