Big Data, Big Challenges, and Big Ideas

in 21st Century Astrostatistics

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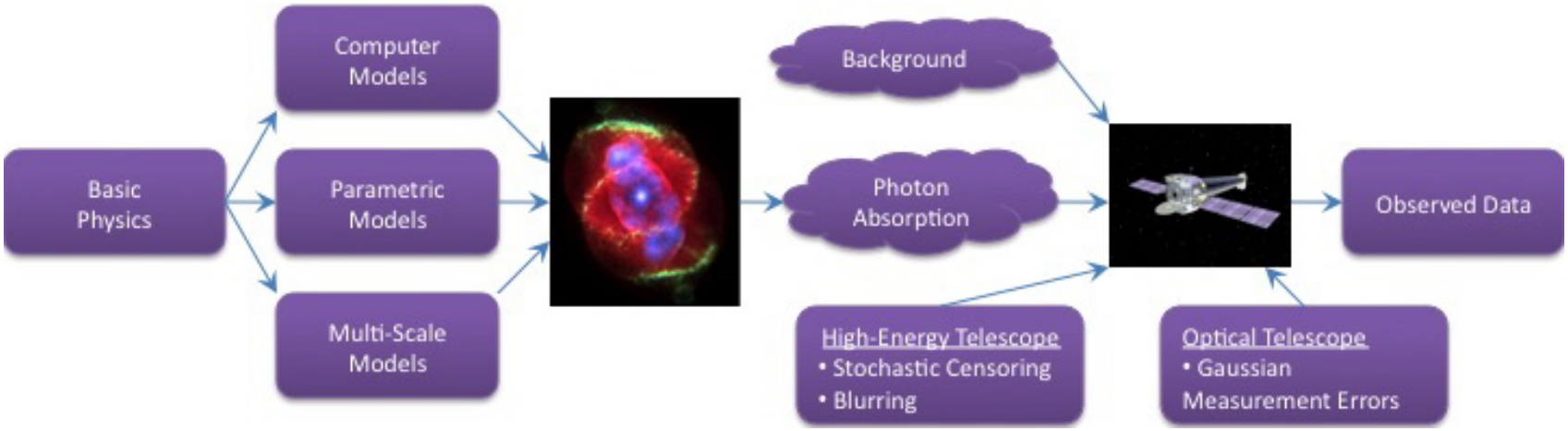
Complexity



- Complex physics, complex models, complex instruments, and complex questions.
- New reliance on state-of-the-art statistical methods.
- *Descriptive science-driven* versus *predictive* models.

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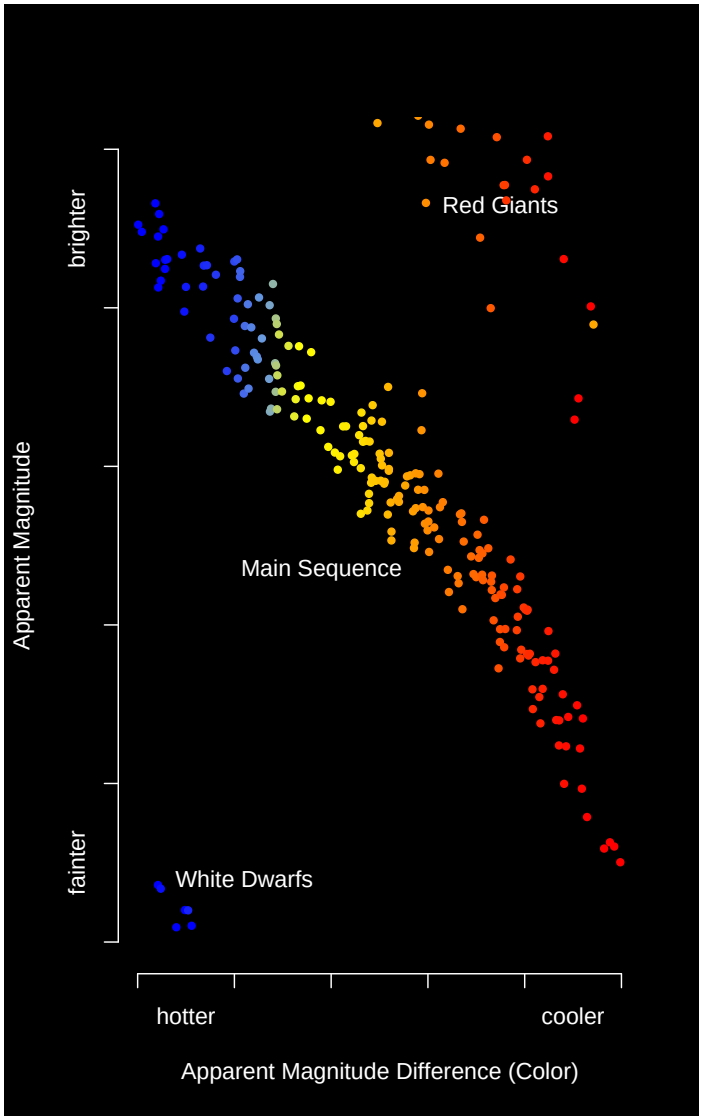
Computer Models



- Complex computer models and simulations are taking the place of the analytic models.
- E.g., to model
  - stellar evolution,
  - planetary, stellar atmospheres
  - reactions in interstellar clouds,
  - the emergence of galactic clusters and superclusters,
  - elements formed in Big Bang.
- Chi-by-eye fitting.
- Principled methods, fitted values, and error bars?

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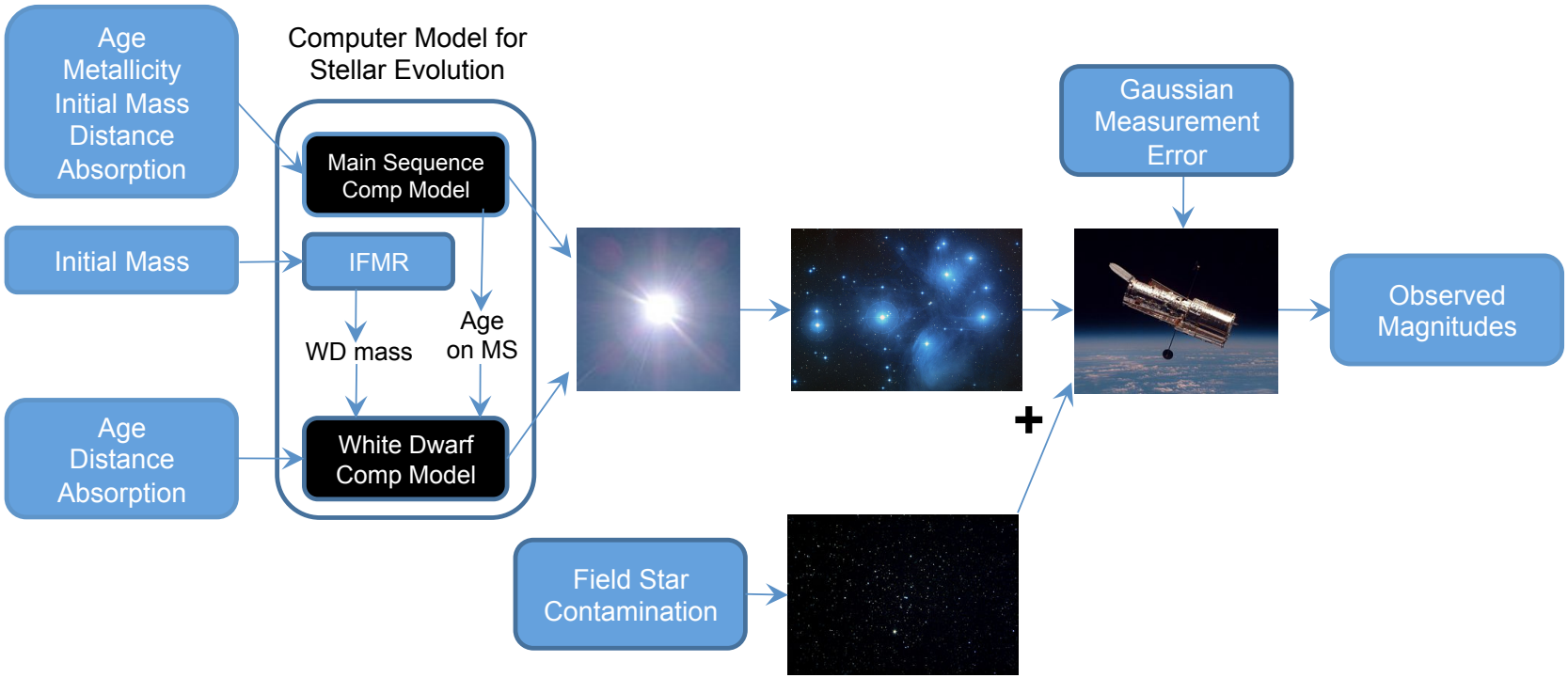
Computer Models



- Embedding ensembles of computer models into a principled multi-level Bayesian model.
- Challenge is acute when complex models are combined with massive data streams.

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Massive ("BIG") Data

- A great leap forward:
  Large Synoptic Survey Telescope (1.28 petabytes/year).
- Data are *not just massive:*
  they are rich, deep, & complex.
- Require specialized models, methods, and computation.
- Big computational challenges.
- Automated data collection and model fitting (photo Z).
- Science-driven data reduction.

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Massive ("BIG") Data

New instruments: *More data than we can analyze!*

Should more resources be devoted to computational facilities and methodological development?

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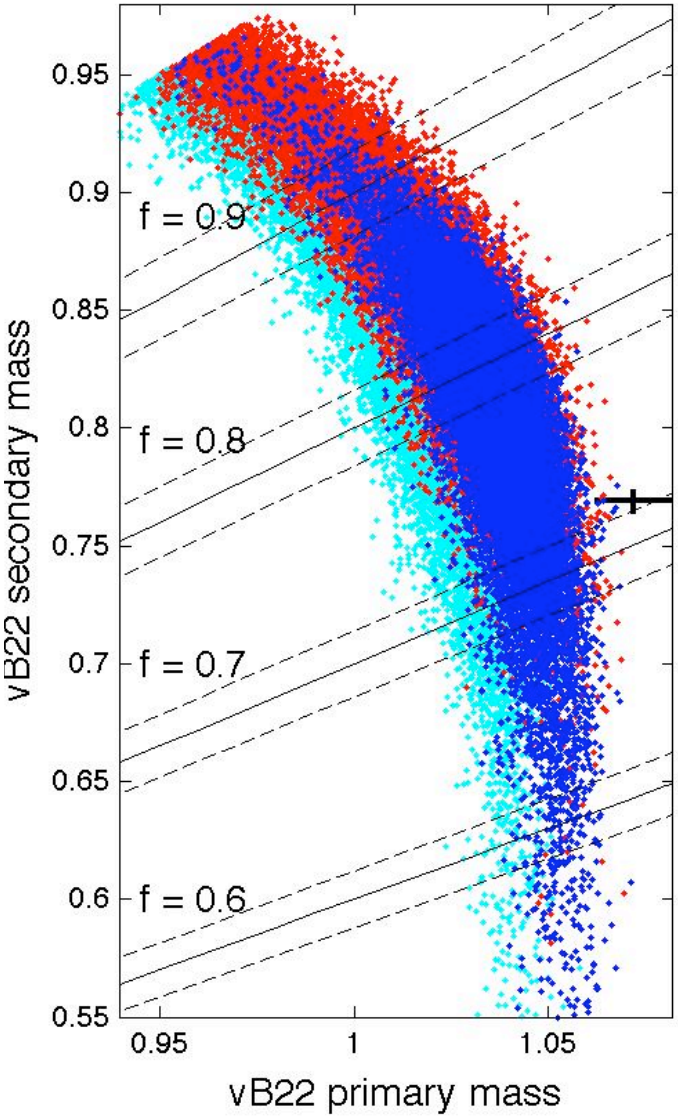
Systematic Errors



- More and more data sources can be used to compare results.
- With ever larger datasets, systematic errors may dominate statistical errors.
- Inconsistencies may appear between instruments and/or data sources.

Errors are easier to see, but still difficult to correct!

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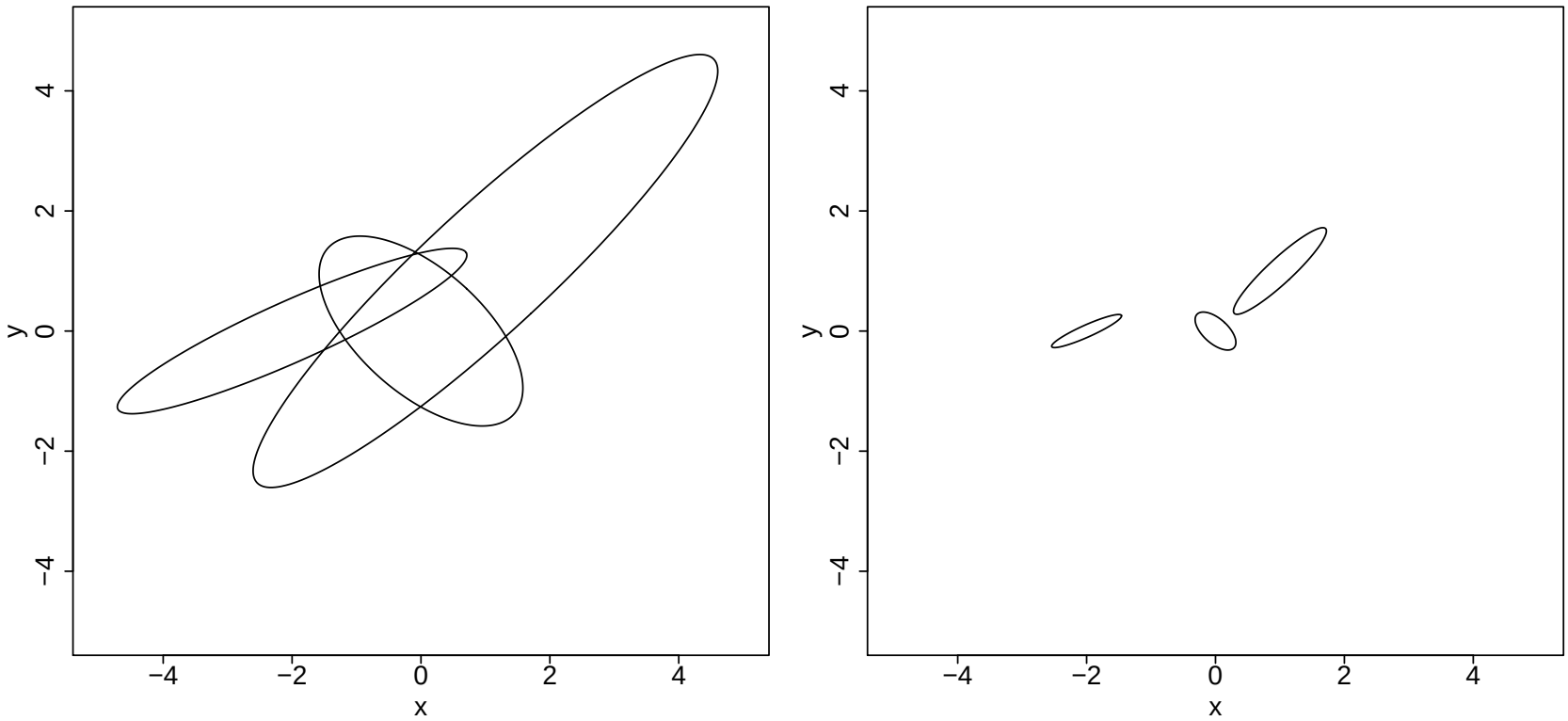
Systematic Errors



As datasets grow, systematic errors swamp statistical errors and new disparities appear.

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