



SIMTOI

A 5D, GPU-accelerated, general purpose modeling tool for
optical interferometry

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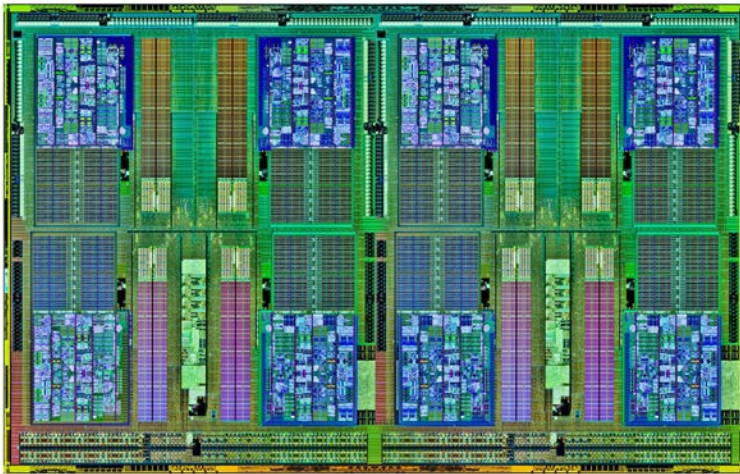
Observatoire
de la COTE d'AZUR



CPU vs. GPU computing

CPU architecture

- Small number of cores (1-64)
- Low memory bandwidth
- Performance: 0.158 TFLOP



GPU architecture

- Massive number of cores (4992 in NVIDIA K80)
- Huge memory bandwidth
- Performance: 1-8 TFLOP





What is SIMTOI?

Simulation and Modeling Tool for Optical Interferometry

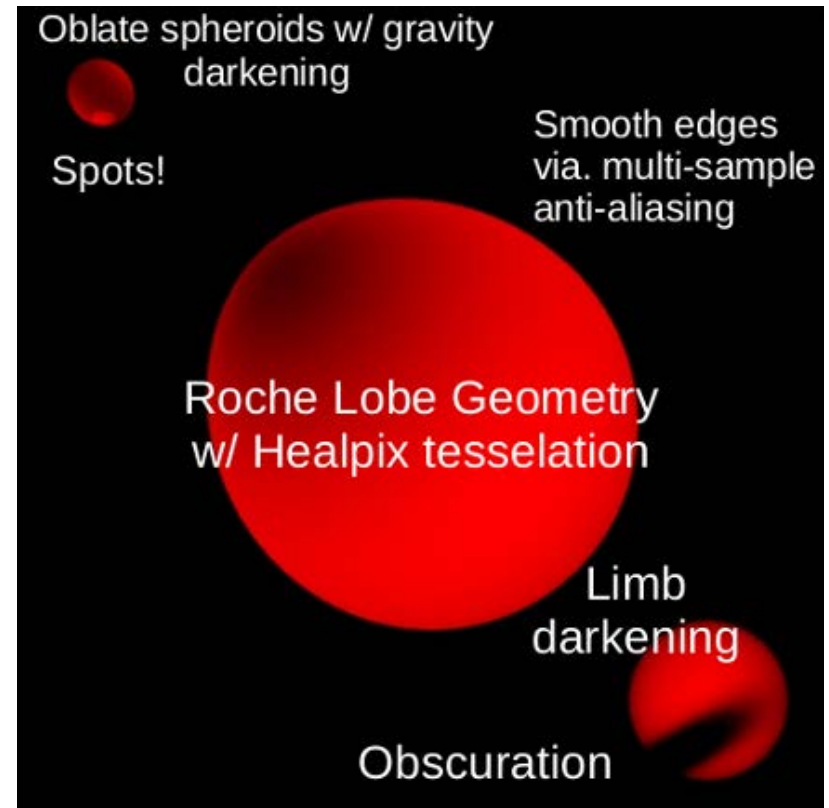
Designed for:

- Sources whose Fourier transform is not easily computed
- Combining multiple data sets and data types
 - Interferometry + photometry + astrometry + SED + ...
- Speed (OpenGL for rendering, OpenCL for computing)
 - 450 model to χ^2 per second (128x128, 2310 UV points)
- Computational accuracy
 - Unit tests to analytical models
- To be used and improved by the community
 - Open source software (GPL v3)
 - Project hosted on GitHub



What can be modeled?

- Stars
 - Spheres
 - Roche surfaces
 - Oblate spheroids
- Stellar surface features
- Limb darkening
 - Claret (2000) four parameter
 - Logarithmic, power law, quadratic, square root
 - Fields (2003) two parameter, flux conserving
- Gravity darkening

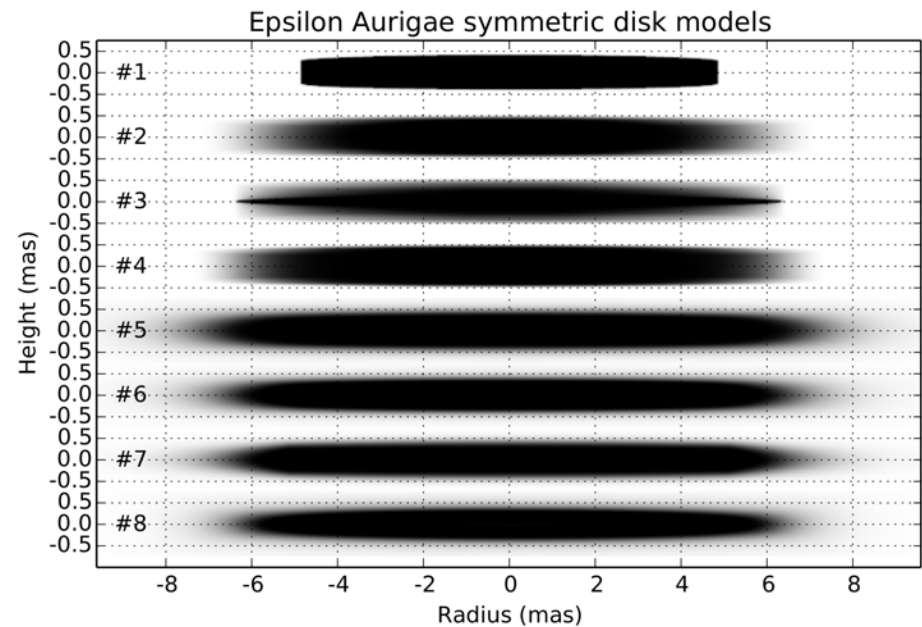




What can be modeled?

Disks!

- Hard-edge cylinder
- Power-law density distribution (unphysical)
- Pascucci (2004) density distribution
- Andrews (2009) density distribution



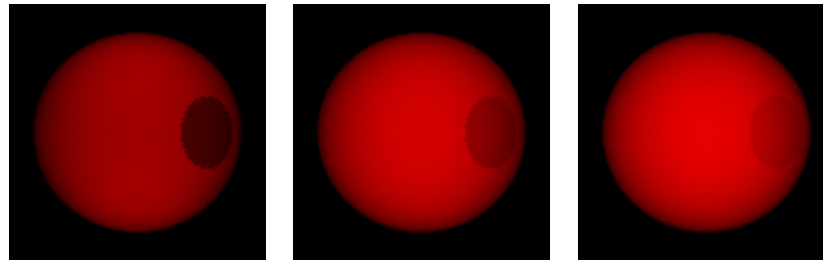
SIMTOI Disk models for eps Aur
from Kloppenborg et al. 2015 (in press)



What can be modeled?

- Time-dependent things
 - Keplerian orbits
 - Solid-body rotation (e.g. for starspots)
 - Pulsation, nova ejecta, etc. (not yet public)
- Wavelength-dependent aspects
 - Blackbody radiation built-in (in develop branch)

5000 K power-law limb darkened star
with 4500 K spot in SIMTOI (flux normalized)



V-band

H-band

N-band



Minimization engines

- Gridsearch: N-dimensional
- Levmar:
 - Least squares (Levenberg-Marquardt)
- MultiNest (Feroz & Hobson 2009):
 - Bayesian nested sampling + hypothesis testing
- Bootstrapping + Levmar
 - Read the documentation before using this!



Demonstration

- A new model: a spotted oblate star
 - Add / edit models
 - Built-in tool-tip help
 - Wavelength slider
 - Animation
 - Add OIFITS and photometric data
 - Snap to date / wavelength feature



Other nice features

- Save format is JSON (common format, human readable)
- Can be scripted via. command line
- Repository contains Python scripts for
 - Plotting data and SIMTOI result files
 - Parsing MultiNest output
 - Interpreting bootstrap results (histogram + error bars)



Coming soon...

- LDD via. Neilson (2011; SATLAS-based) (Ryan)
- Documentation and usability improvements (Rob & Brian)
- Additional minimization engines (Fabien)
- Brian:
 - Packages for Linux (.deb, .rpm, .tar.gz)
 - Intel / AMD integrated GPU support (urgh...)
 - Real-time plots showing model and data values
 - Obnoxiously fast photometry (15,000 image/sec)
 - Faster OIFITS simulation via. NUFFT on GPUs
 - New tessellation of spheres (triangular subdivision)
- <your name here>
 - Apple support (port to QT5)
 - More documentation, demos, how-to-guide



Where to learn more

SIMTOI repository:

<https://github.com/bkloppenborg/simtoi>

Documentation is on the SIMTOI wiki:

<https://github.com/bkloppenborg/simtoi/wiki>

Ask an experienced SIMTOI user

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Fabien, Rob