



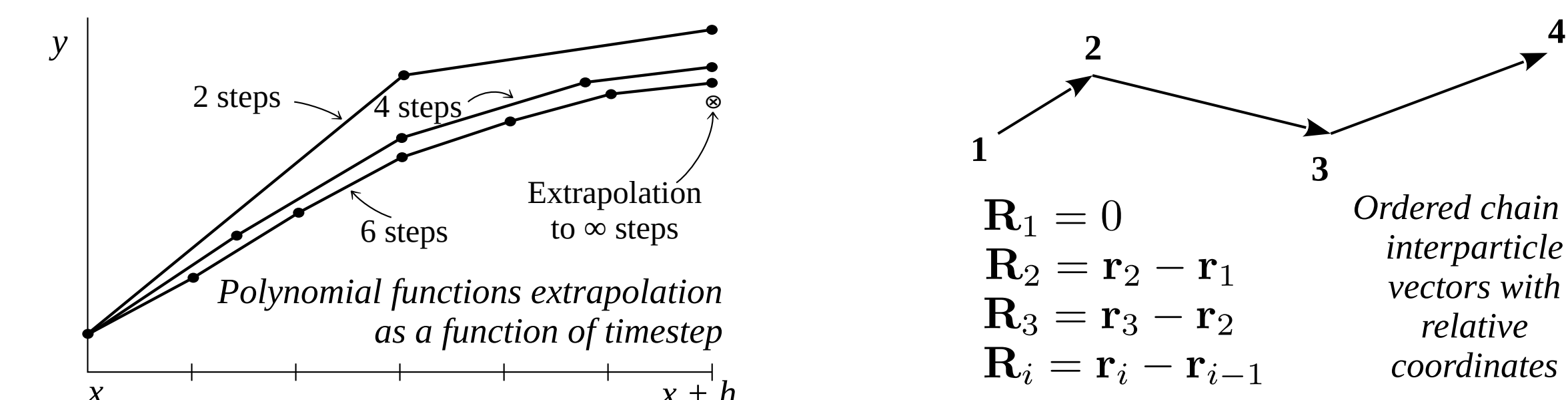
# TSUNAMI: a modern, user-friendly few-body code for the dynamics of hierarchical systems

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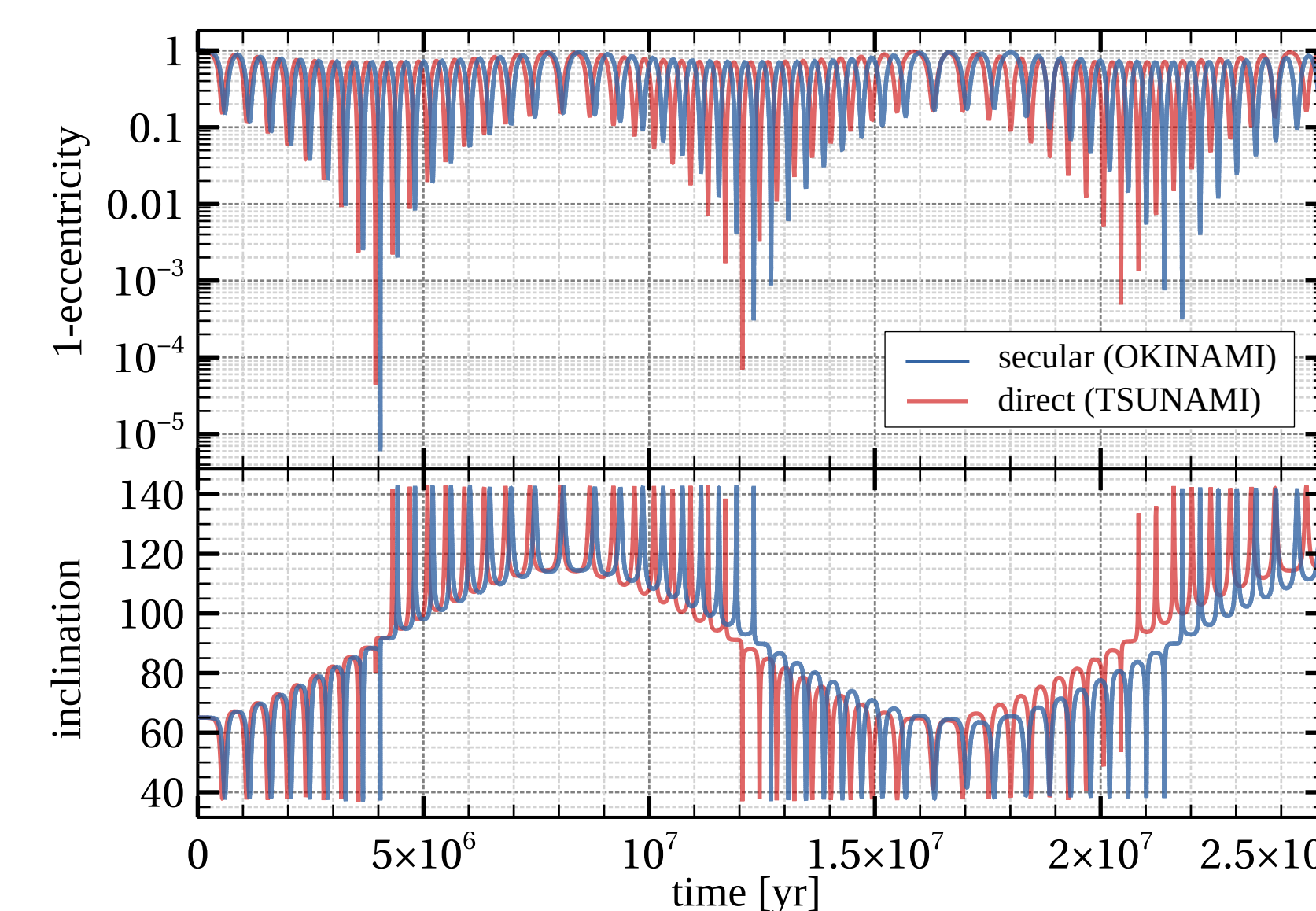
- Fast and accurate**
- Bulirsch–Stoer extrapolation: excellent accuracy over a broad dynamical range



- Chain coordinate system: **no round-off errors** when two close particles are far from the center of mass (e.g. close encounters or hierarchical systems)
- Time-transformed leapfrog: **timestep is not reduced** during close encounters, no slowdown of integration for high eccentricities and scatterings
- Adaptive timestep: uses **short timesteps only when needed**. Accuracy threshold can be tuned based on the desired integration time
- Fills the gap among existing codes: slower than Wisdom-Holman methods (e.g. WHFAST), but not limited by high eccentricity/close encounters. **Much faster** than high-order Runge-Kutta methods (e.g. IAS15)
  - Over **10× faster** than similar implementations (e.g. ARCHAIN)

**Versatile**

- Run TSUNAMI through its **Python interface**, or as a standalone C++ code
  - Out-of-the-box support for **velocity-dependent forces**:
    - ✓ Post-Newtonian terms (1, 2 and 2.5PN)
    - ✓ Equilibrium & dynamical tide
  - REBOUND support: wrappers to use REBOUND integrators with TSUNAMI's I/O
- Collisions detection, restart, job queue submitter and many other **quality-of-life** features
- Comes with its **secular counterpart** OKINAMI. Solves the **double-averaged** equations of motions of the hierarchical 3-body problem, including tides and post-Newtonian effects



► Kozai-Lidov oscillations in a hierarchical triple system (Jupiter+Sun+Brown Dwarf, see Naoz et al. 2013),  
OKINAMI vs TSUNAMI comparison

• In active development: more features are being added based on requests and needs. Suggestions welcome!

**Ideally suited for**

- Scatterings simulations
- Kozai-Lidov evolution in hierarchical triples
- Black hole dynamics
- Complex hierarchical systems with high mass ratios
- Tidally evolving stellar/planetary systems

**Join our git repository and Slack channel!!**

Papers that use TSUNAMI:

arXiv:2102.09323 arXiv:1908.07535  
arXiv:2102.01689 arXiv:1904.07879  
arXiv:2101.03661 arXiv:1809.07339  
arXiv:2008.13778 arXiv:1809.01968  
arXiv:2004.05475

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