

High-precision dynamic orbit integration for spaceborne gravimetry

Matthias Ellmer, Torsten Mayer-Gürr
Institute of Geodesy, WG Theoretical Geodesy and Satellite Geodesy
NAWI Graz, TU Graz

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Variational equation approach

For the simpler case of single-satellite observations.

Observations

- Satellite position r (from GNSS)
- Force model \ddot{r} (from accelerometer, background models, ...)

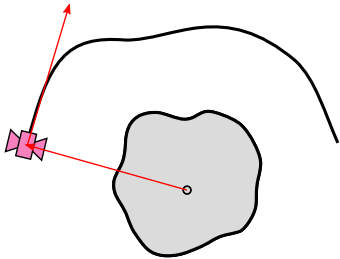
Unknown variable:

Gravity field parameters

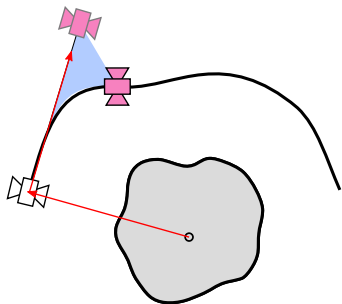
Equation of motion connects position and acting forces:

$$r(t) = r_0 + \dot{r}_0 \cdot (t - t_0) + \iint_{t_0}^t \ddot{r}(\tau) d\tau$$

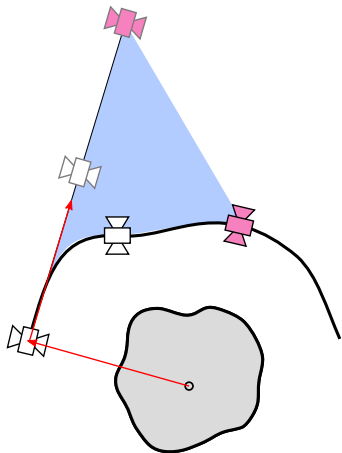
Reference motion



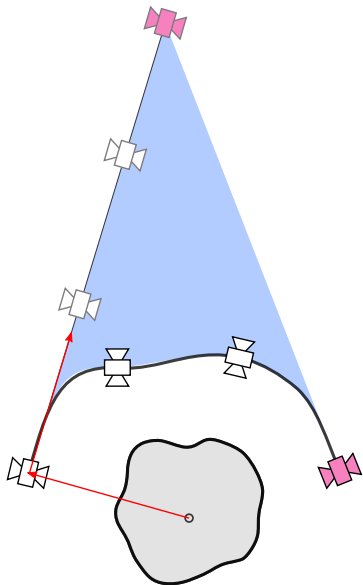
Reference motion



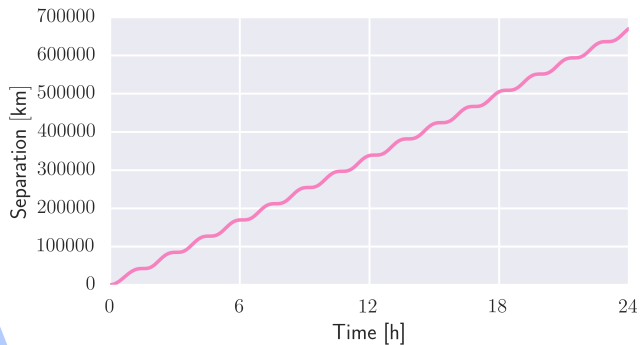
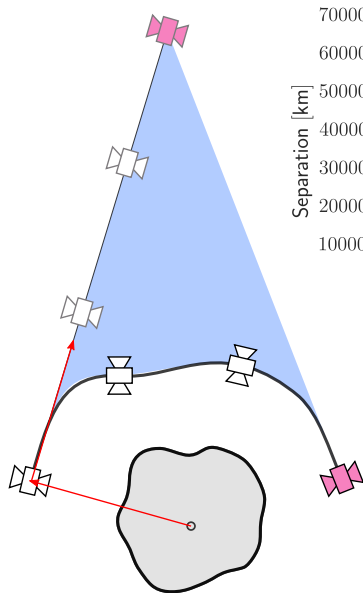
Reference motion



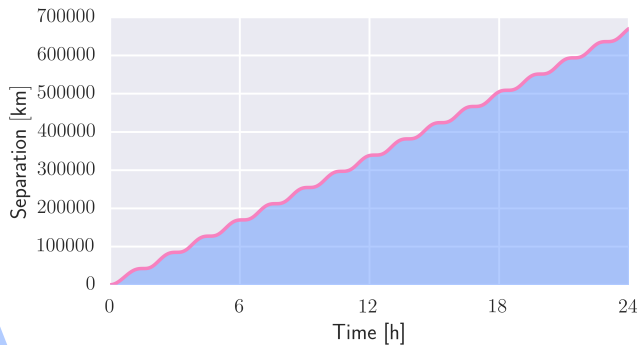
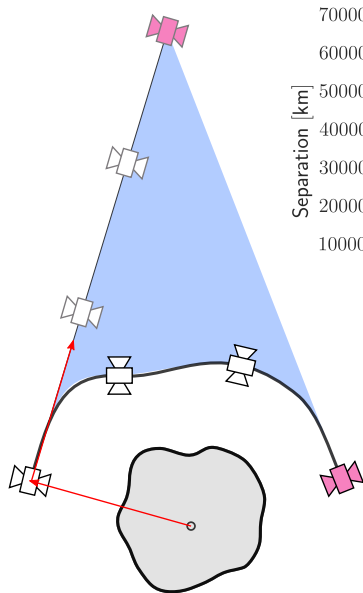
Reference motion



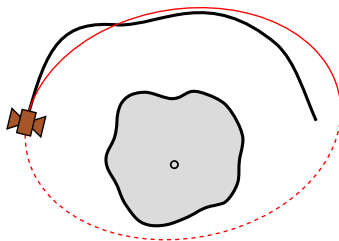
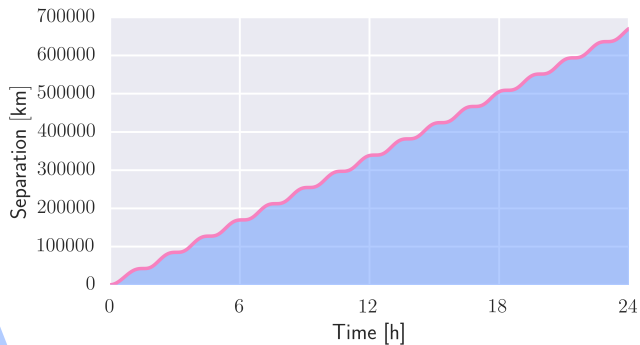
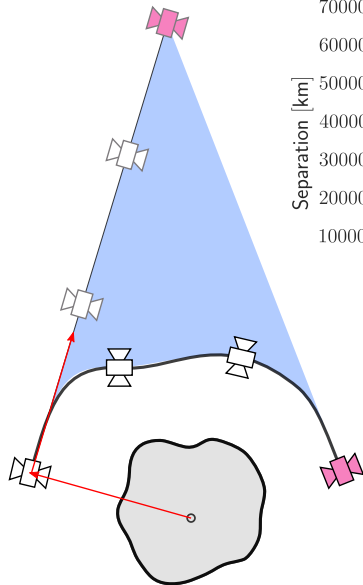
Reference motion



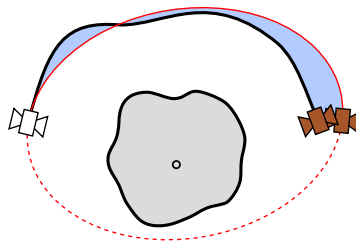
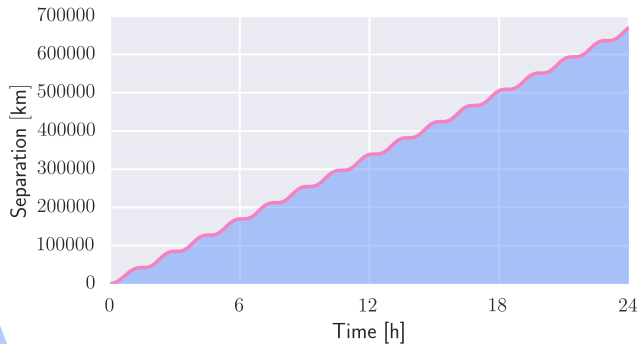
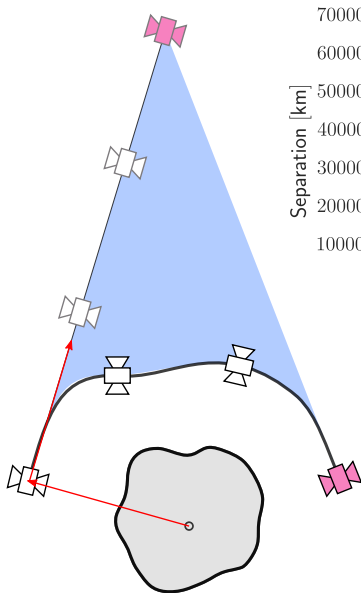
Reference motion



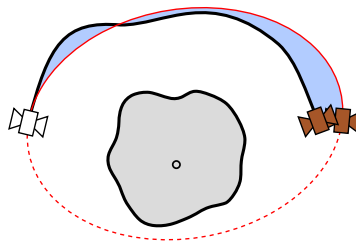
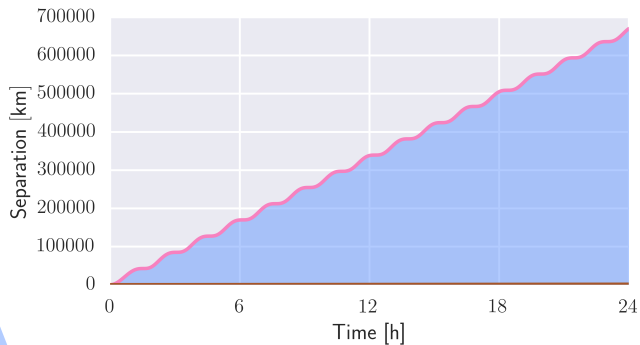
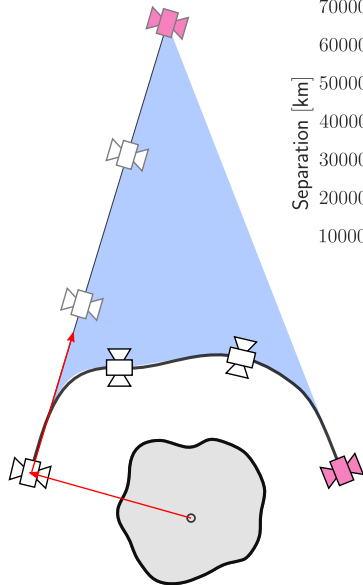
Reference motion



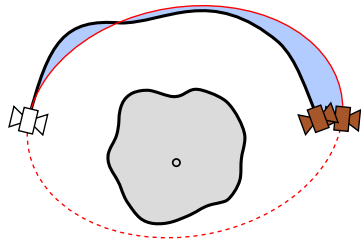
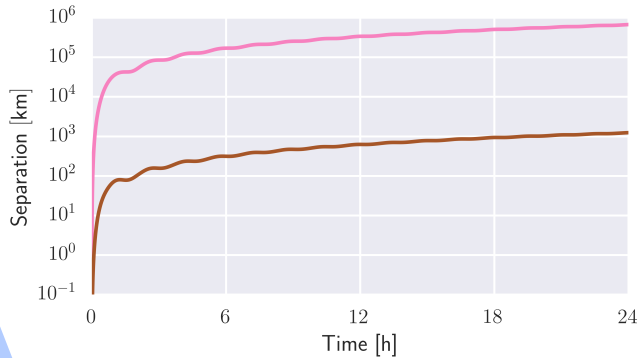
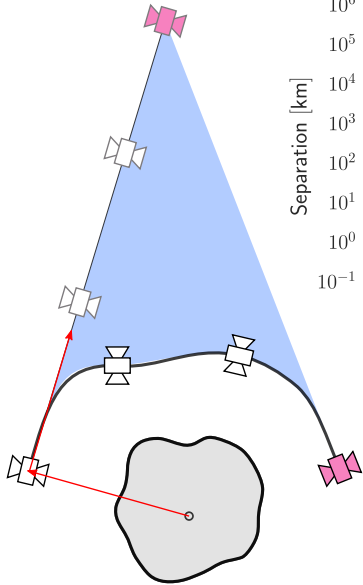
Reference motion



Reference motion



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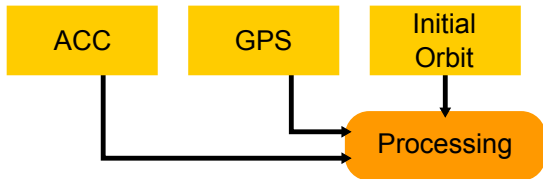
Dynamic orbit determination is iterative

ACC

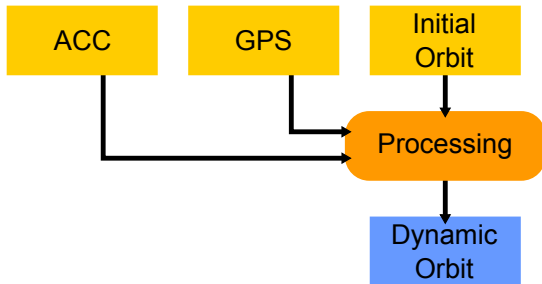
GPS

Initial
Orbit

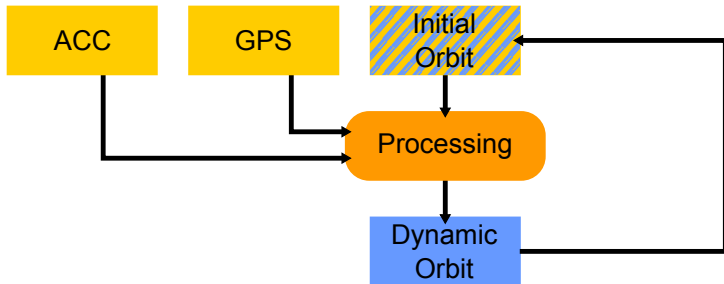
Dynamic orbit determination is iterative



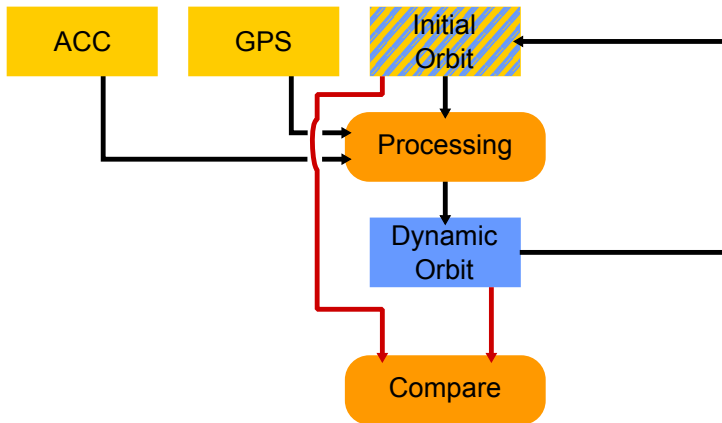
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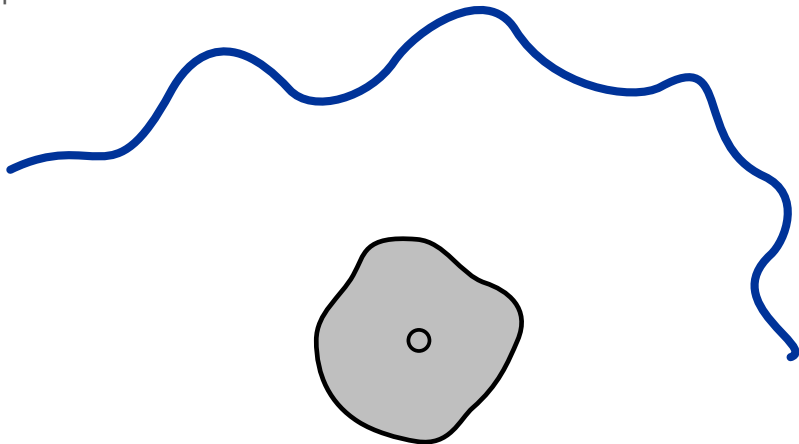


Dynamic orbit determination is iterative



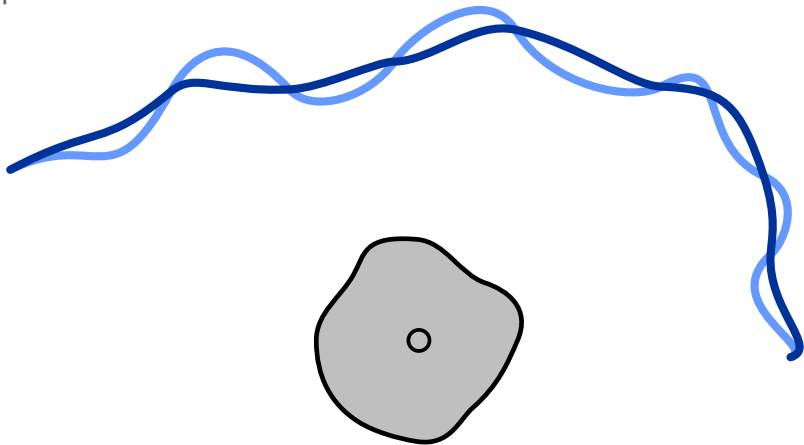
Convergence of dynamic orbit

Expectation: After convergence, dynamic orbit is invariant through multiple iterations.



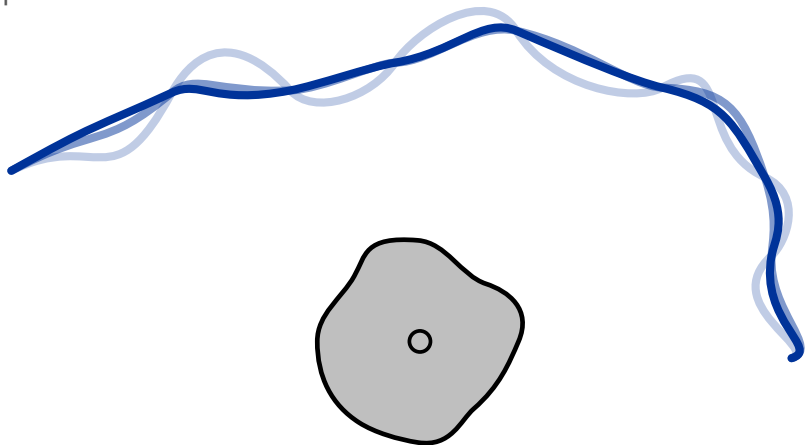
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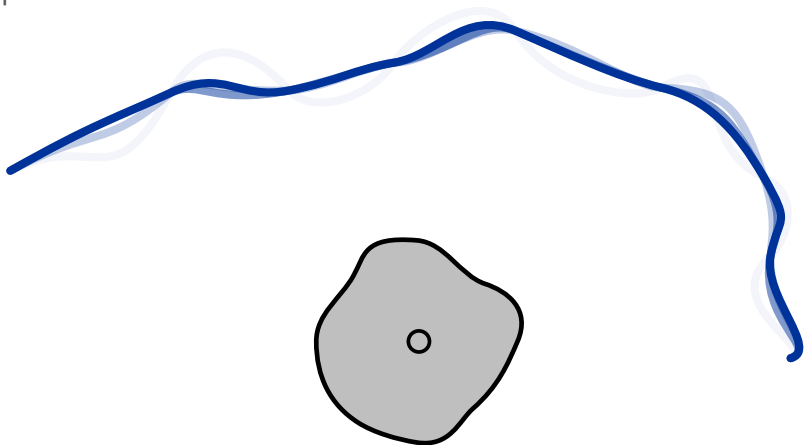
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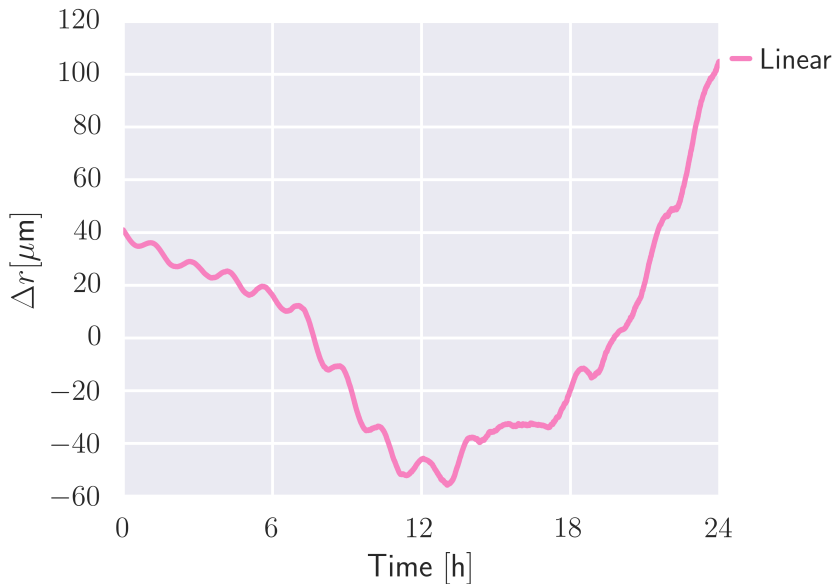


Convergence of dynamic orbit

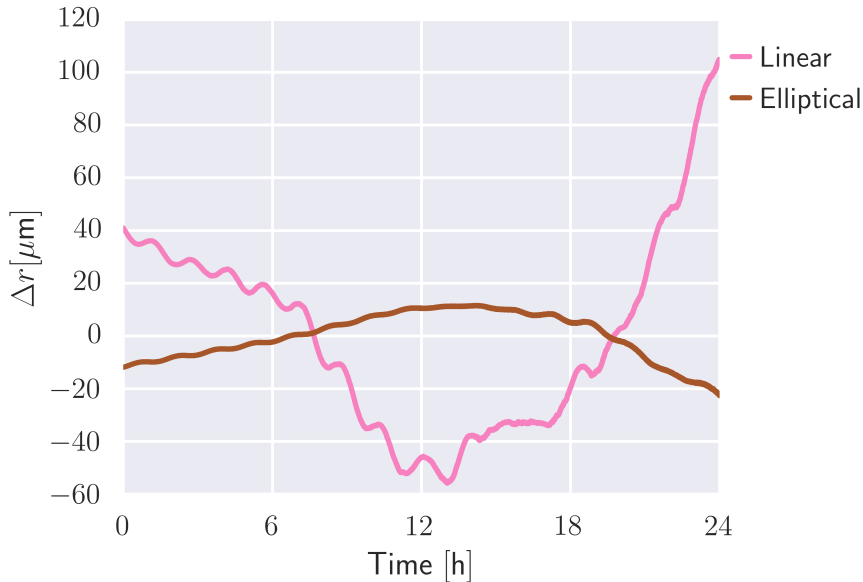
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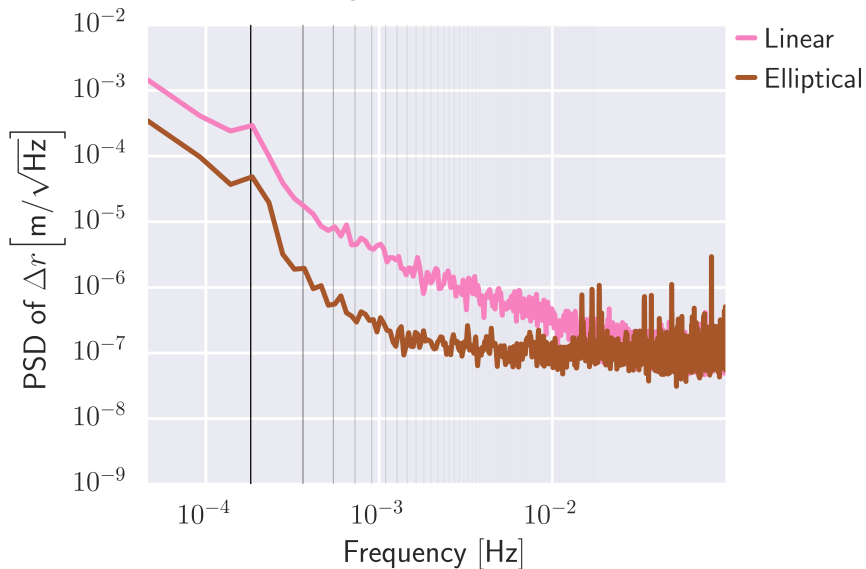
Simulation in d/o 60 potential



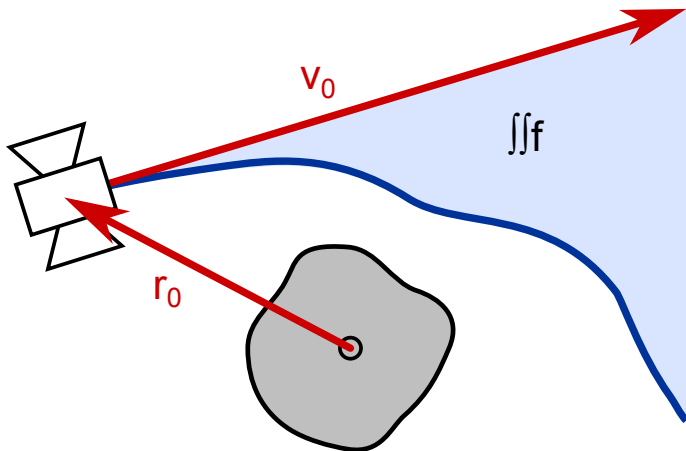
Simulation in d/o 60 potential



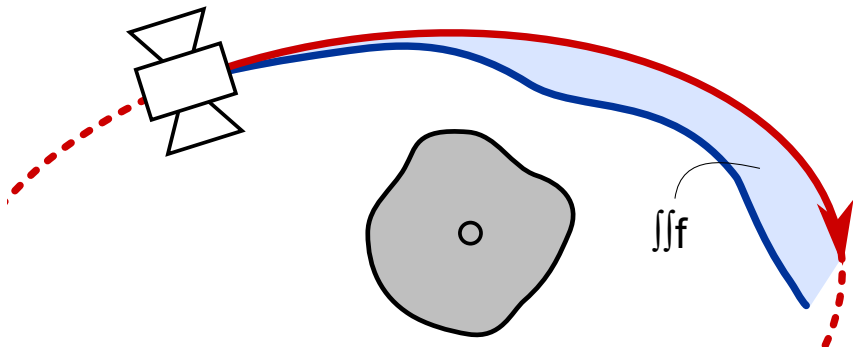
Simulation in d/o 60 potential



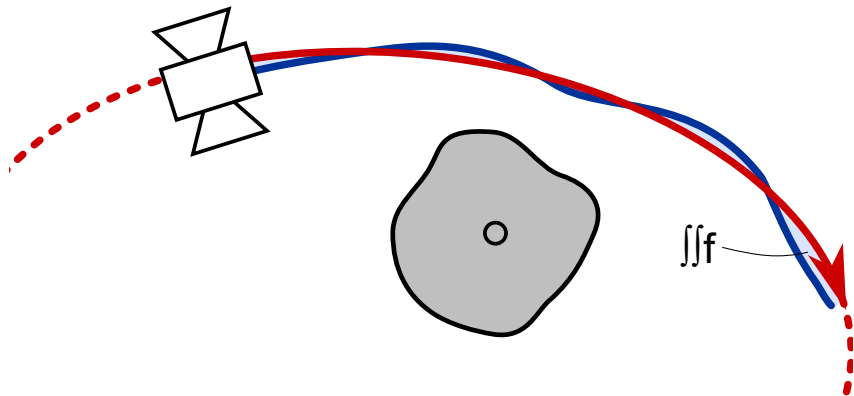
Optimization of reference trajectory



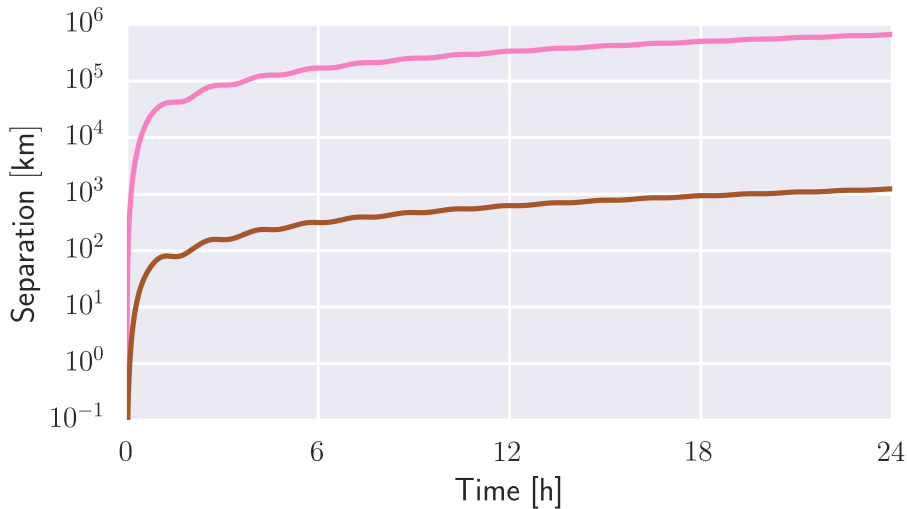
Optimization of reference trajectory



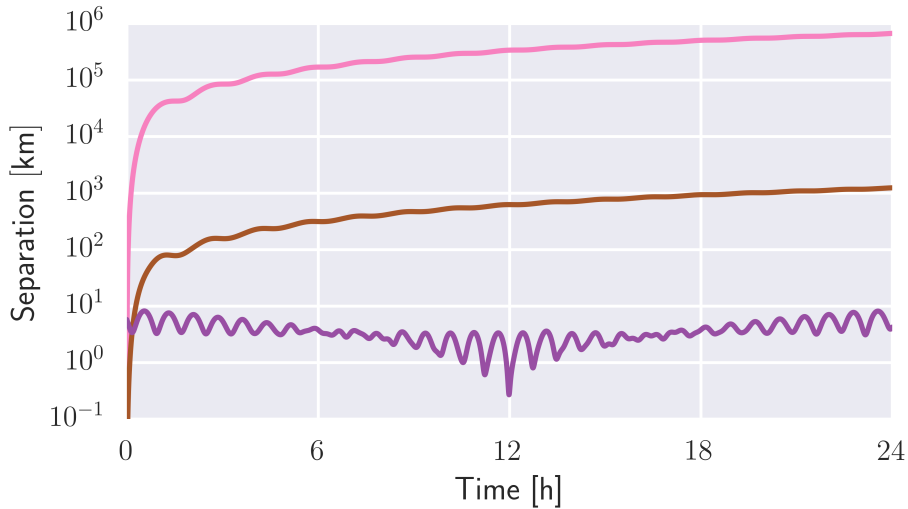
Optimization of reference trajectory



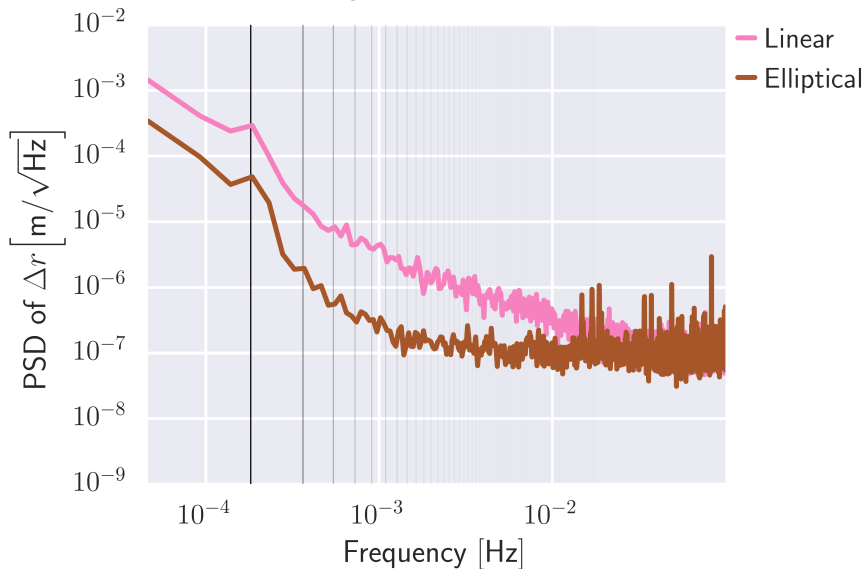
Optimal ellipsis



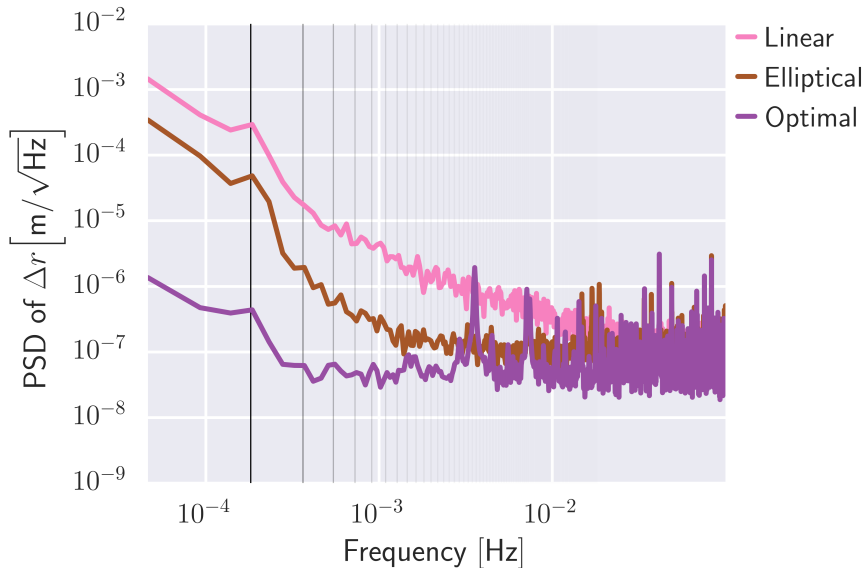
Optimal ellipsis



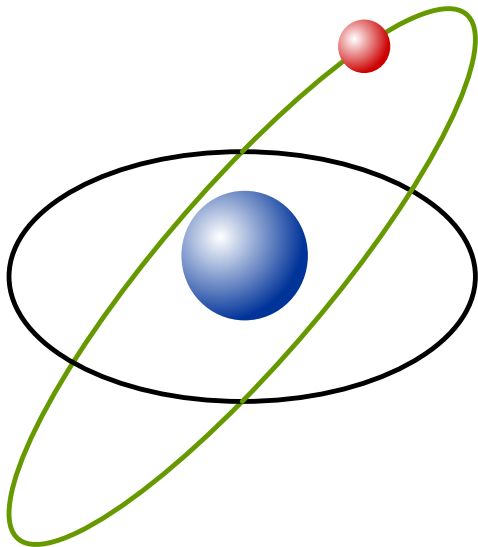
Simulation in d/o 60 potential



Simulation in d/o 60 potential



Parametrization of reference ellipses



From: Kepler elements

$a, e, I, \omega, \Omega, M$

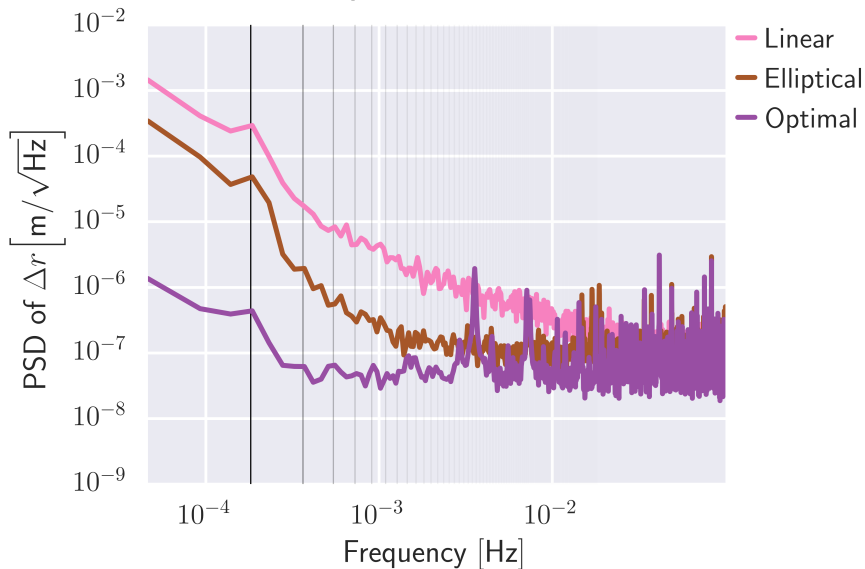
To: Equinoctial elements

a, h, k, p, q, λ

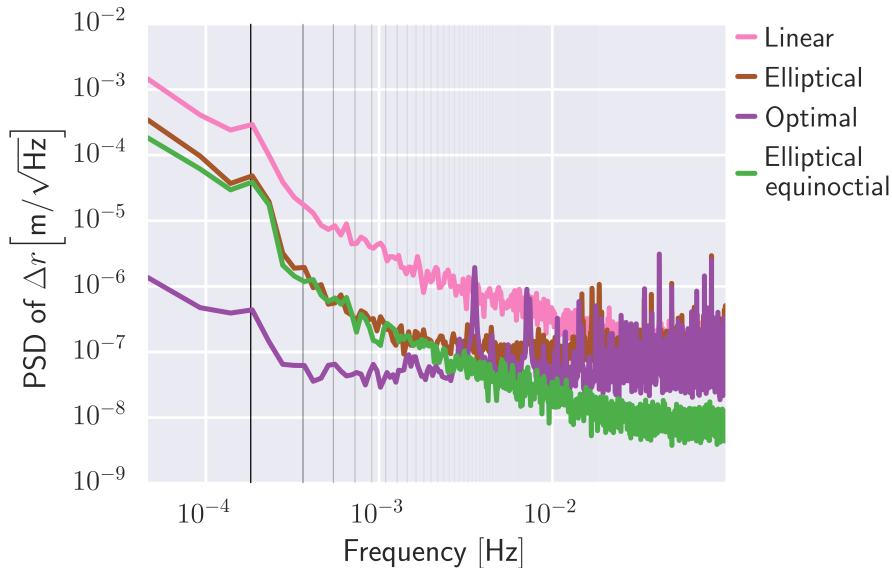
Advantage

Numerical stability and precision.

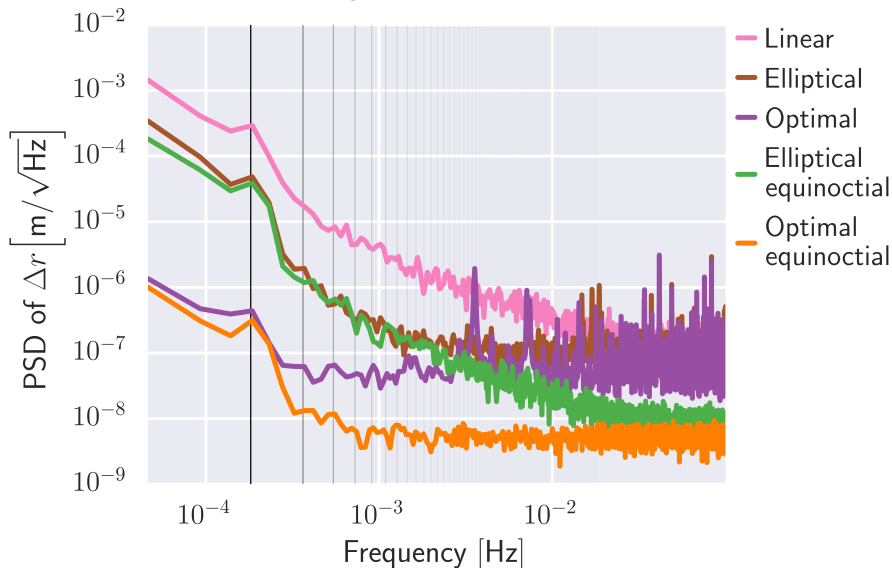
Simulation in d/o 60 potential



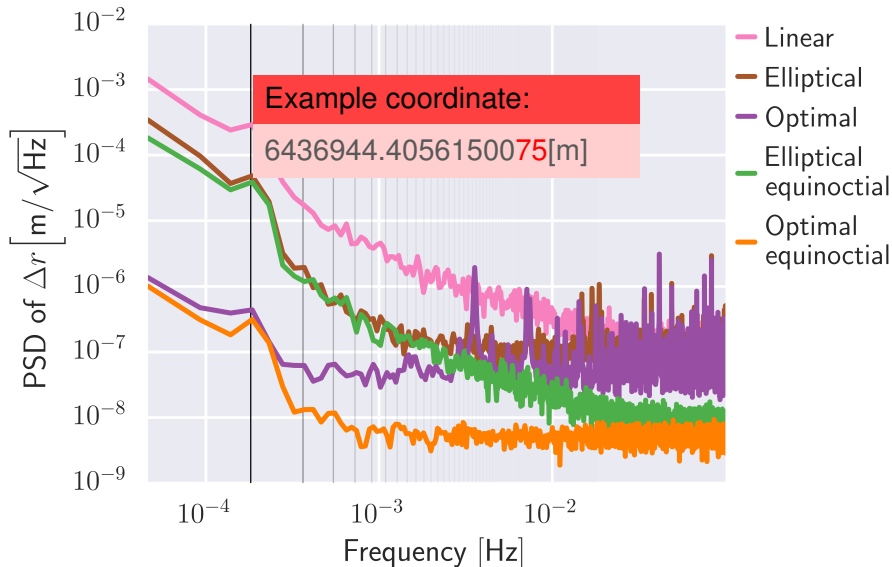
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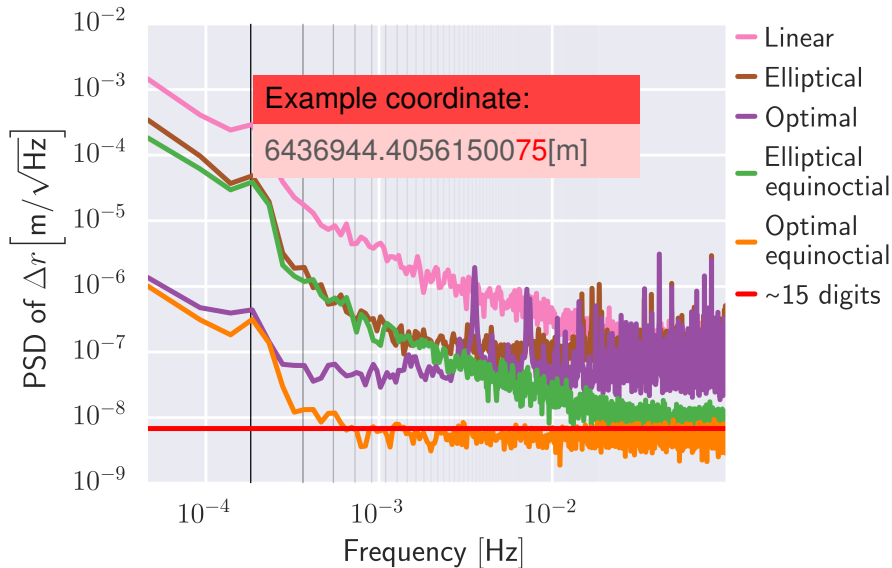
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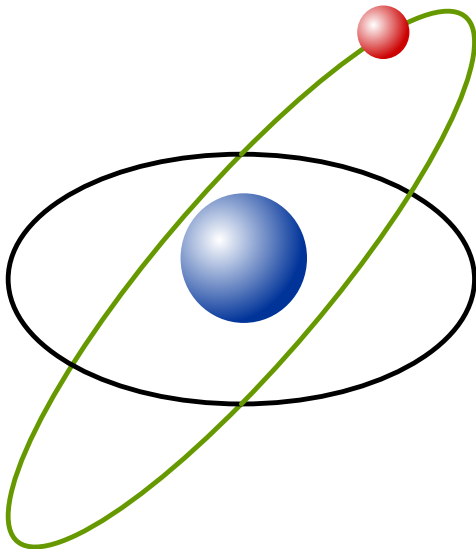
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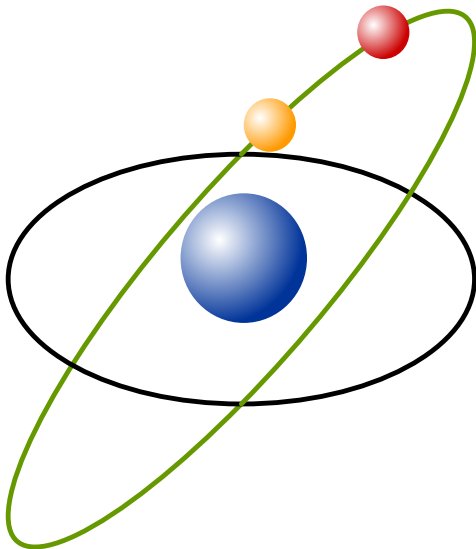
Simulation in d/o 60 potential



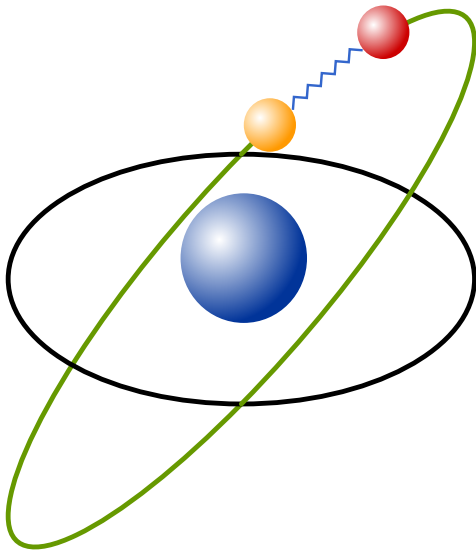
Propagation of error estimate to range rate



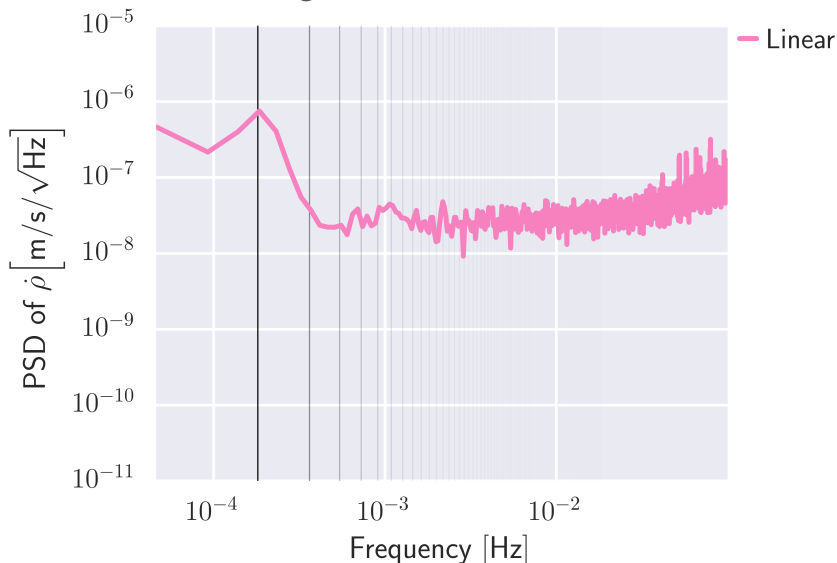
Propagation of error estimate to range rate



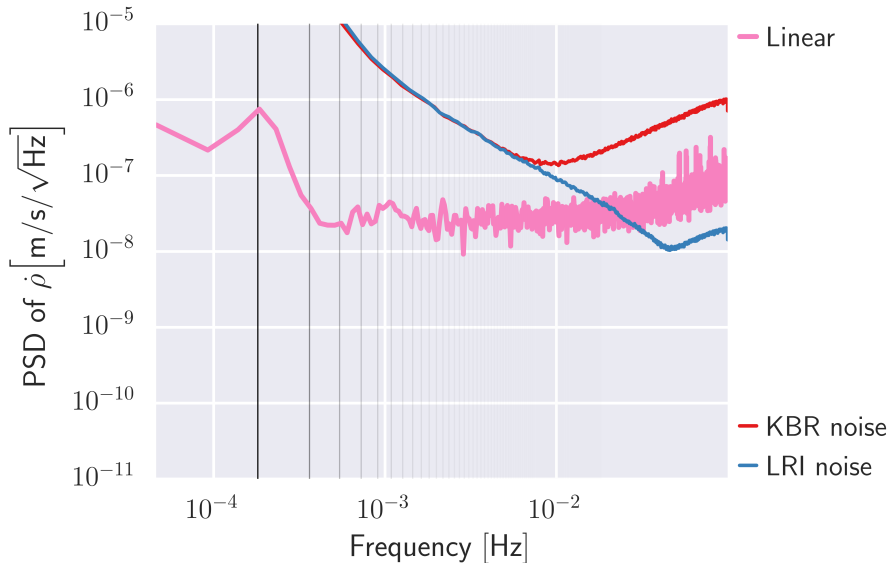
Propagation of error estimate to range rate



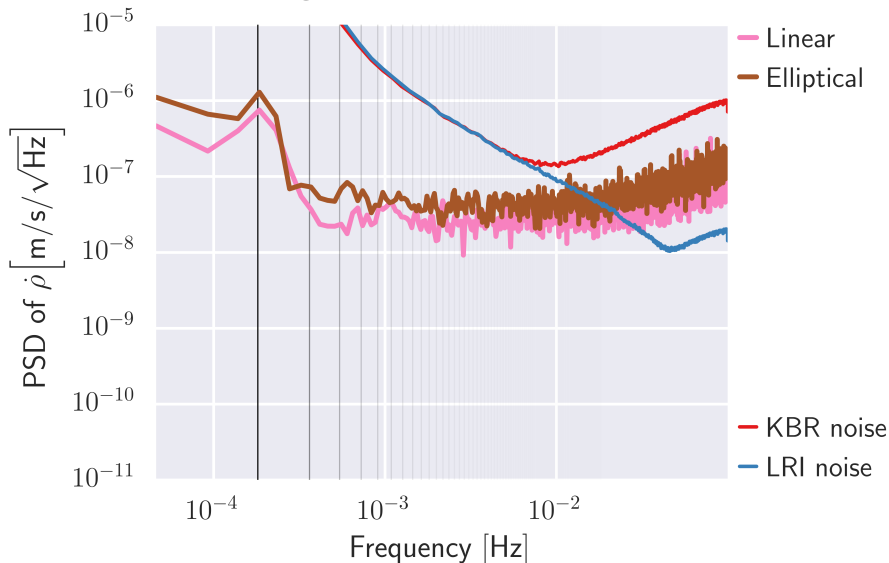
Real data — Range rate error estimate



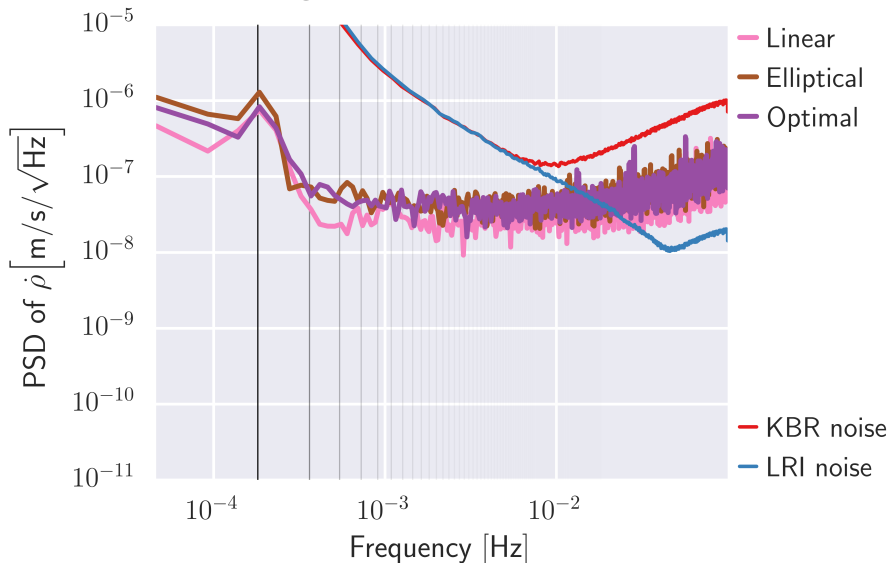
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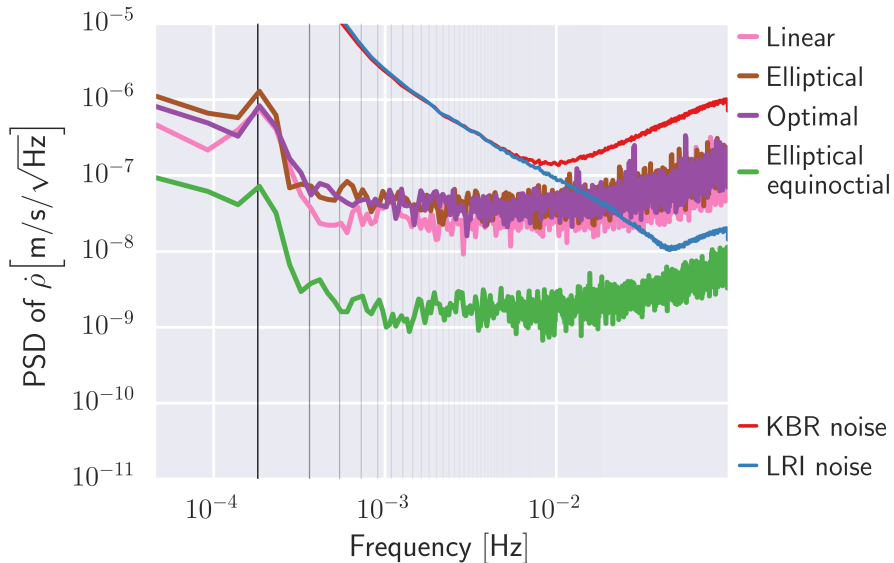
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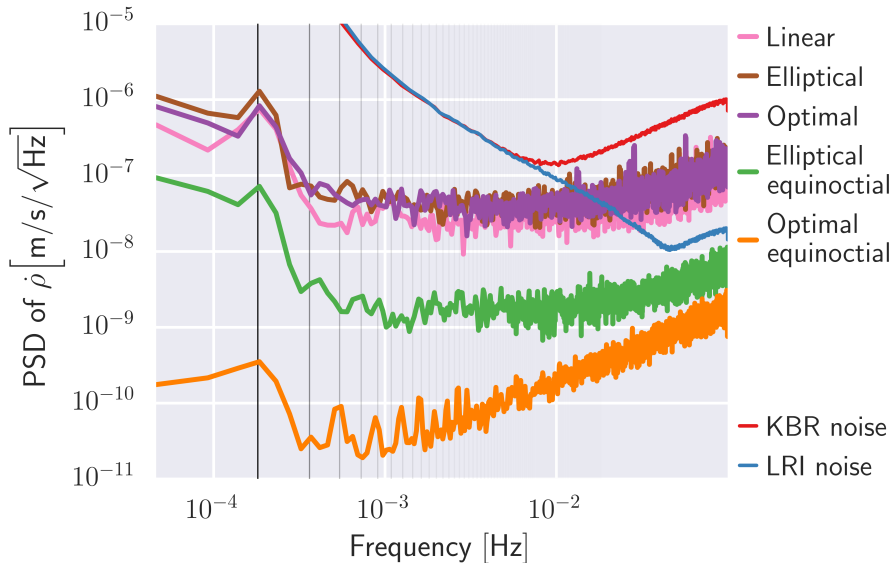
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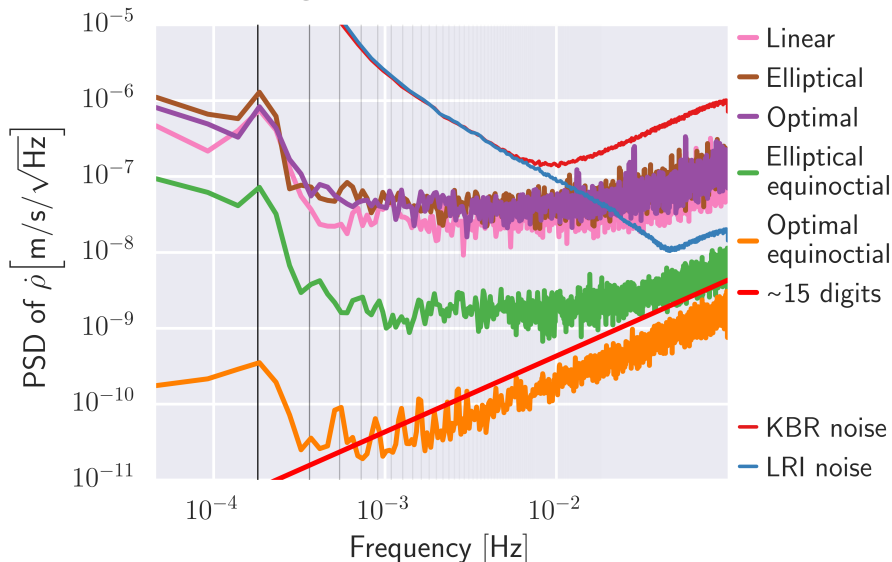
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Conclusion

