

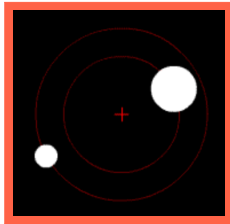
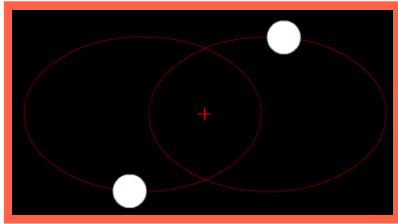
**What is...numerical dynamics?**

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Or: Subfields of mathematics 32

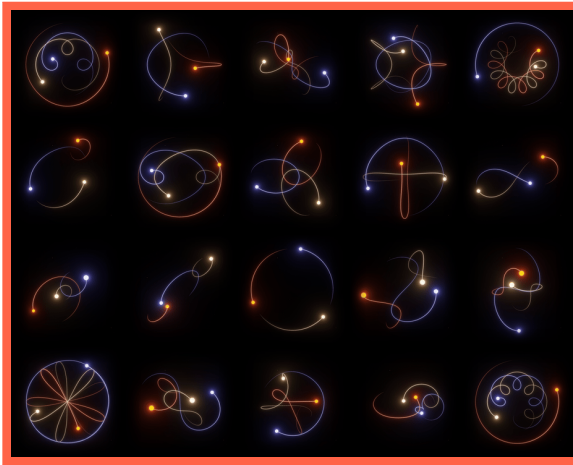
## Two bodies (e.g. sun, earth)

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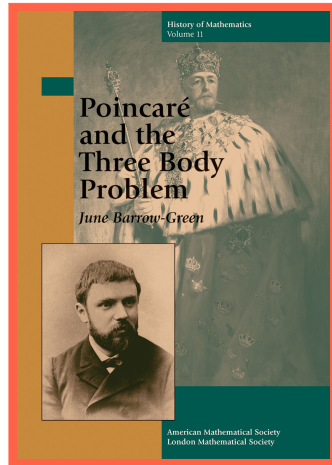
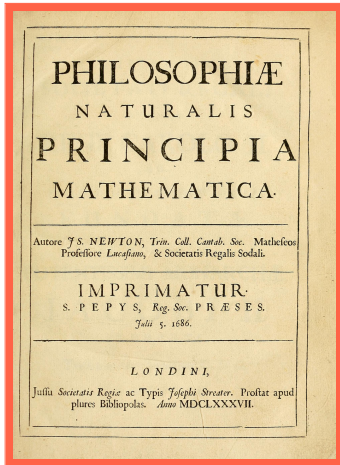
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- ▶ Two body problem = predict the motion of two bodies orbiting each other
  - ▶ Above Binary stars; Pluto and Charon
  - ▶ The solutions are quite easy to obtain

## Three bodies (e.g. sun, earth, moon)



- ▶ Three body problem = predict the motion of three bodies orbiting each other
- ▶ Above Stable orbits of three equal masses
- ▶ The solutions are next to impossible to obtain

# N bodies

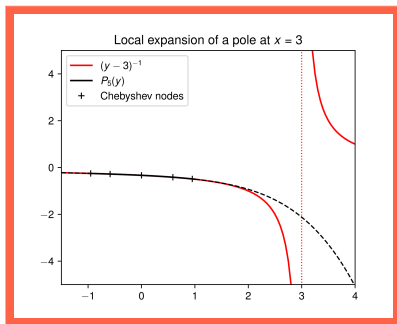


- ▶ The corresponding N body problem was originally posed by Newton
- ▶ Finding the solutions was considered very important and challenging
- ▶ Poincaré discovered chaotic deterministic systems while studying the three body problem

## Enter, the theorem

FMM computes solutions of the N body problem in  $O(N \log 1/\epsilon)$

- ▶  $\epsilon > 0$  is a fixed tolerance
- ▶ Fast multipole method (FMM) is a numerical technique that was developed to speed up the calculation of long-ranged forces
- ▶ This works by expanding the system Green's function via multipole expansion



- ▶ Numerical dynamics answers similar questions!

# Algorithms of the century



- Metropolis Algorithm for Monte Carlo
- Simplex Method for Linear Programming
- Krylov Subspace Iteration Methods
- The Decompositional Approach to Matrix Computations
- The Fortran Optimizing Compiler
- QR Algorithm for Computing Eigenvalues
- Quicksort Algorithm for Sorting
- Fast Fourier Transform
- Integer Relation Detection
- Fast Multipole Method

► Above From the IEEE Computer Society Journal

► No such list can be perfect but that FMM made it on it should tell us something 😊

**Thank you for your attention!**

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I hope that was of some help.