

Solving Physics Problems on a Computer

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Perimeter Institute for Theoretical Physics

Lunch and Learn
May 5, 2016

Agenda (time permitting)

1 Throwing Darts for π

2 Planetary Orbits a la Newton

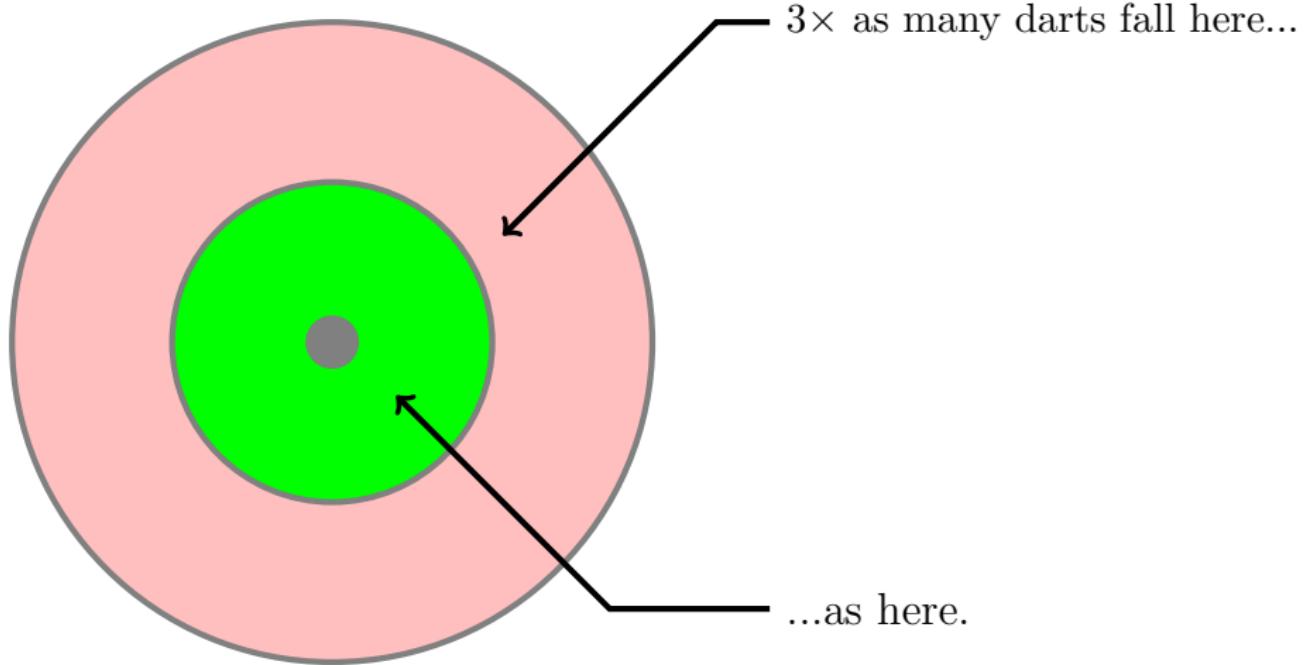
3 Structure of a Star

The Random Darts Player

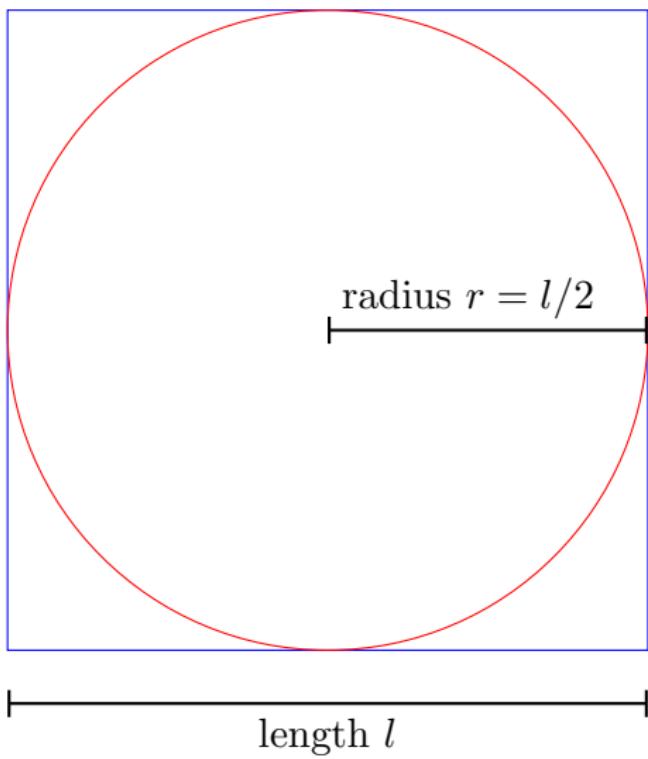


Source: Wikimedia Commons

The Darts Tell us the Area of the Ring!



Areas and π



Area of the circle:

$$A_c = \pi \frac{l^2}{4}$$

Area of the square:

$$A_{sq} = l^2$$

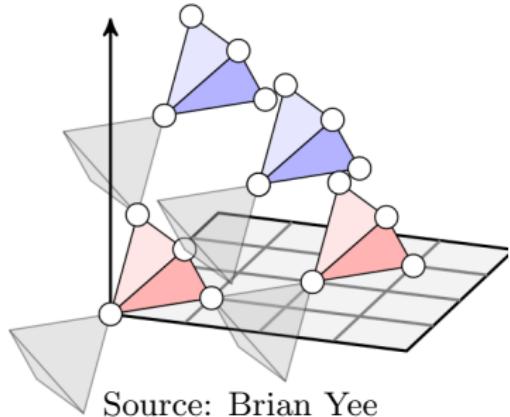
Therefore:

$$\pi = 4 \frac{A_c}{A_{sq}}$$

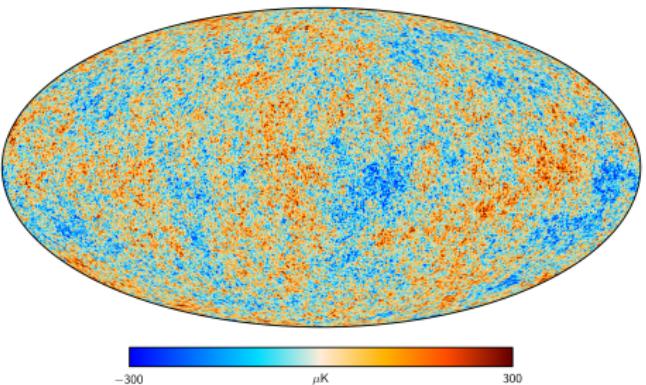
Darts and π

$$\pi \approx 4 \frac{\text{number of darts in circle}}{\text{number of darts in square}}$$

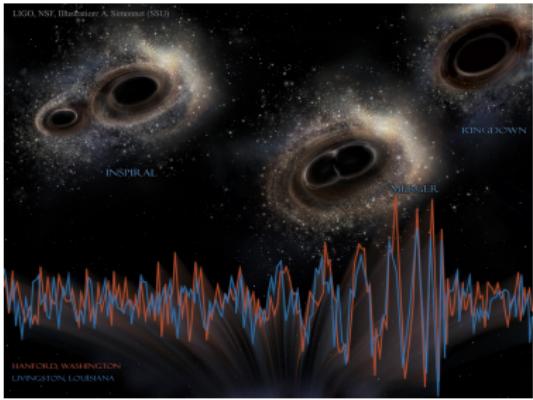
Applications



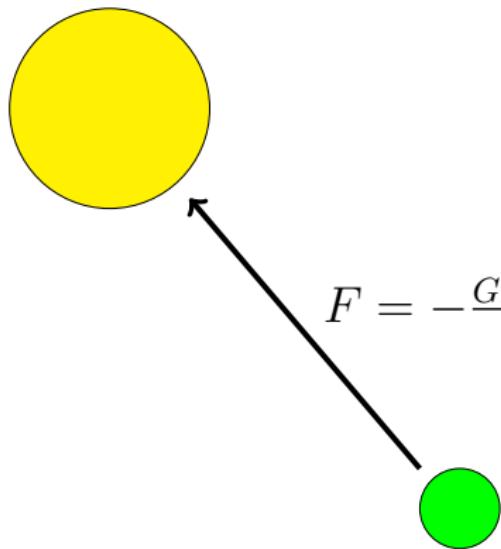
Source: Brian Yee



Source: Planck Collaboration



Newton's Laws



$$F = -\frac{GMm}{r^2}\hat{r}$$

$$F = ma$$

\approx change in speed

change in position \approx speed

Predict the Future Given Information Now

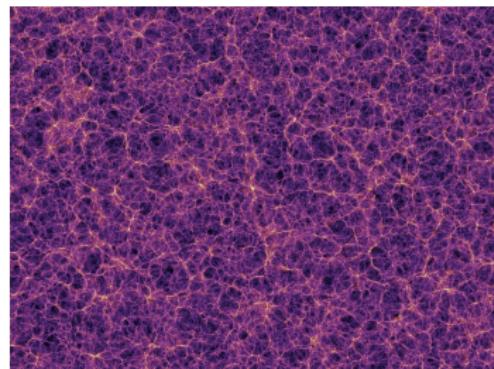
What we have now	What we get in the future
position (x, y)	velocity (v_x, v_y)
velocity (v_x, v_y)	position (x, y)

The Iterative Algorithm: Forward Euler

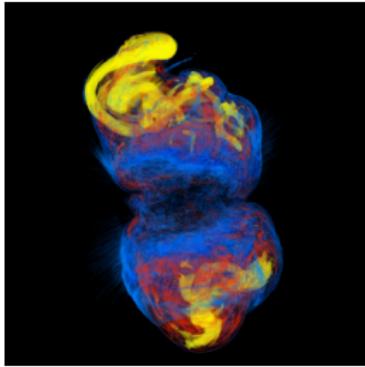
```
for i in range(1,num_times):
    # update positions
    x[i] = x[i-1] + vx[i-1]*dt
    y[i] = y[i-1] + vy[i-1]*dt
    # update velocities
    ax,ay = get_acceleration(x[i-1],y[i-1])
    vx[i] = vx[i-1] + ax*dt
    vy[i] = vy[i-1] + ay*dt
```

Results

Applications

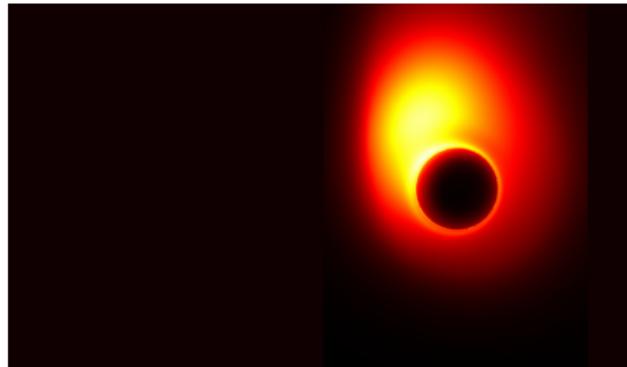


Source: Millennium Simulation

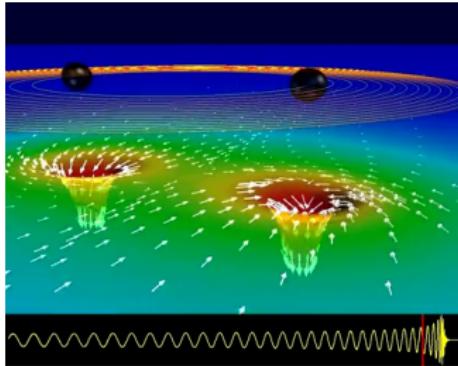


Source: Mösta et al.

J. Miller (PI)



Source: Avery Broderick



Source: The SXS Collaboration

Comp. Phys.

Lunch & Learn

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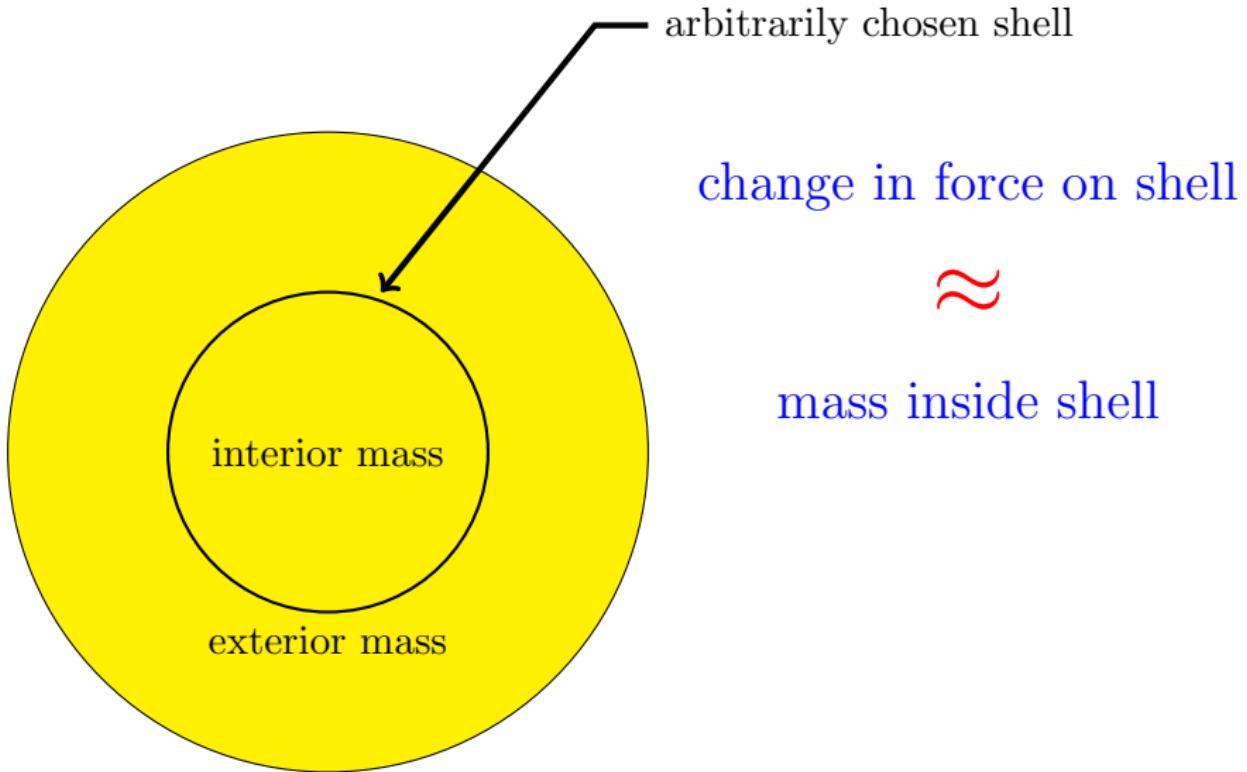
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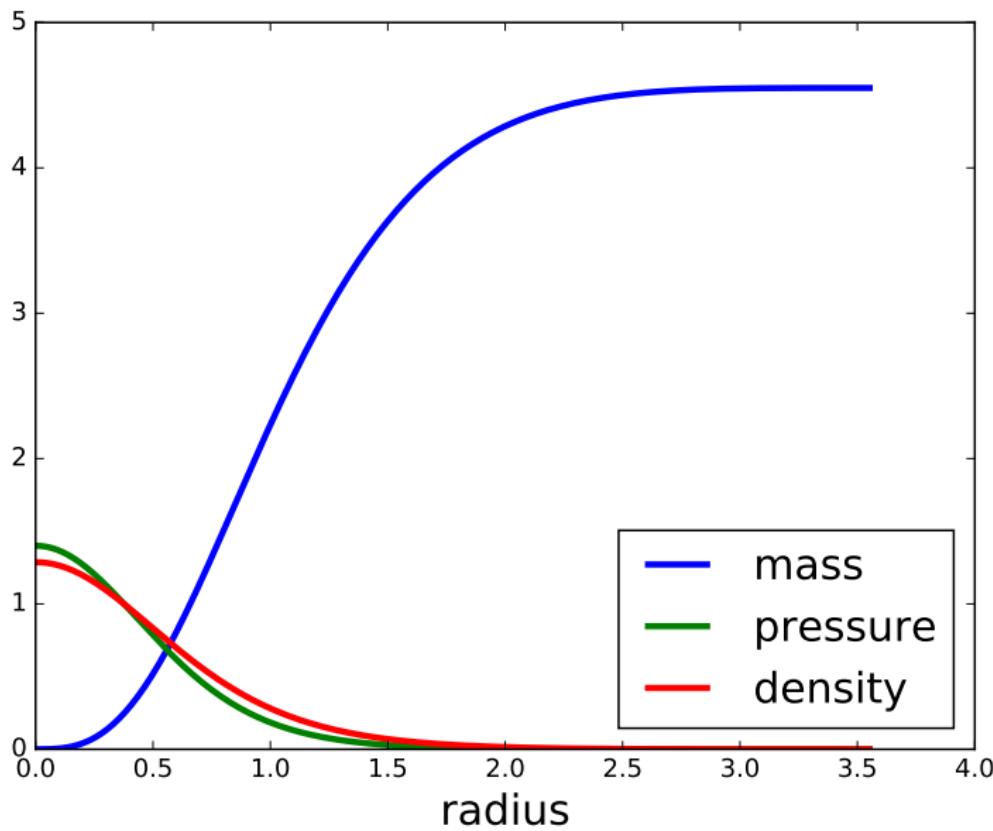
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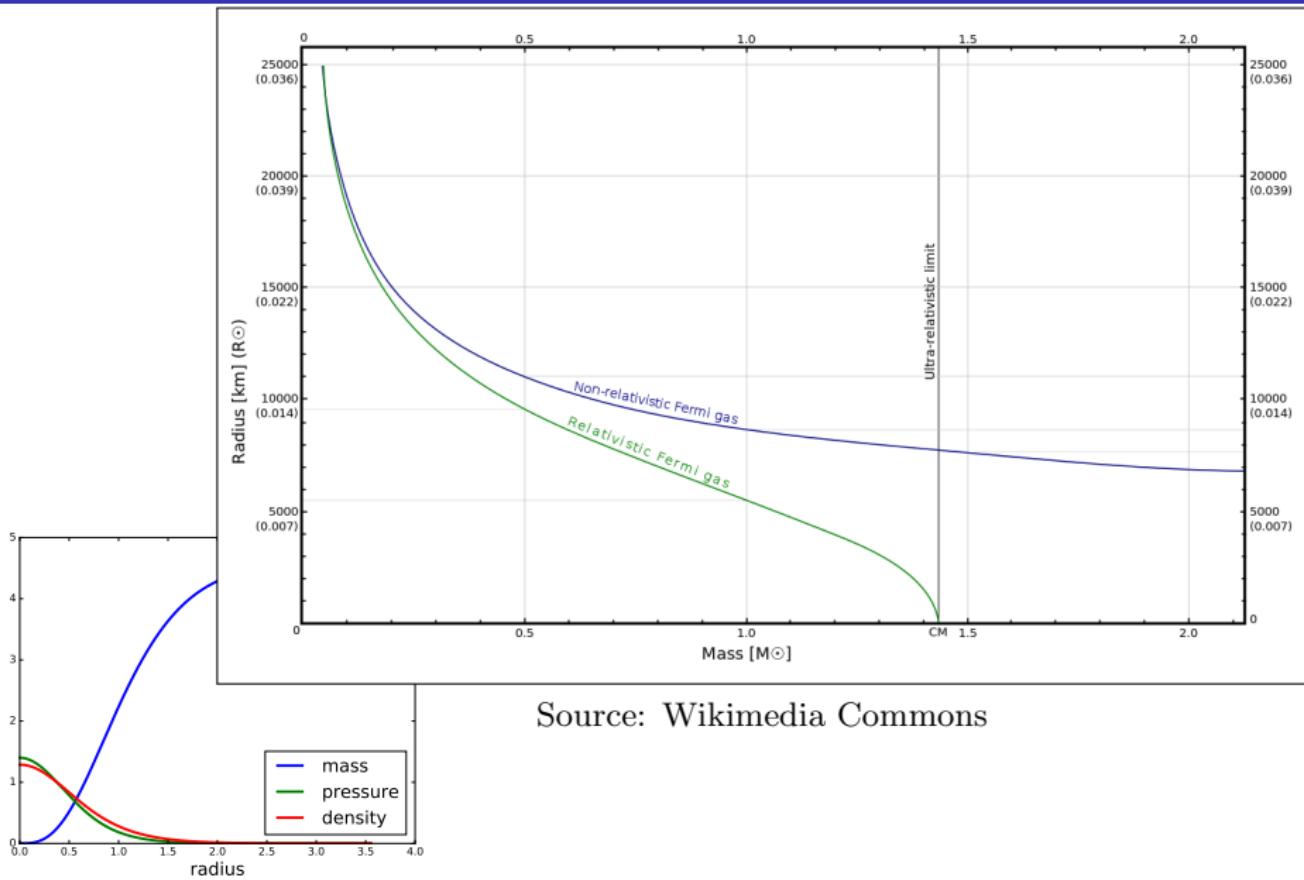
Seeing Inside a Star



Mass, Radius



Mass, Radius



- These slides:

<https://github.com/Yurlungur/computational-physics-demos>

- Monte Carlo for π :

https://bitbucket.org/Yurlungur/pi_monte_carlo

- Newton's Laws:

<https://github.com/Yurlungur/forward-euler-demo>

- Stellar Structure:

<https://github.com/Yurlungur/stellar-structure>