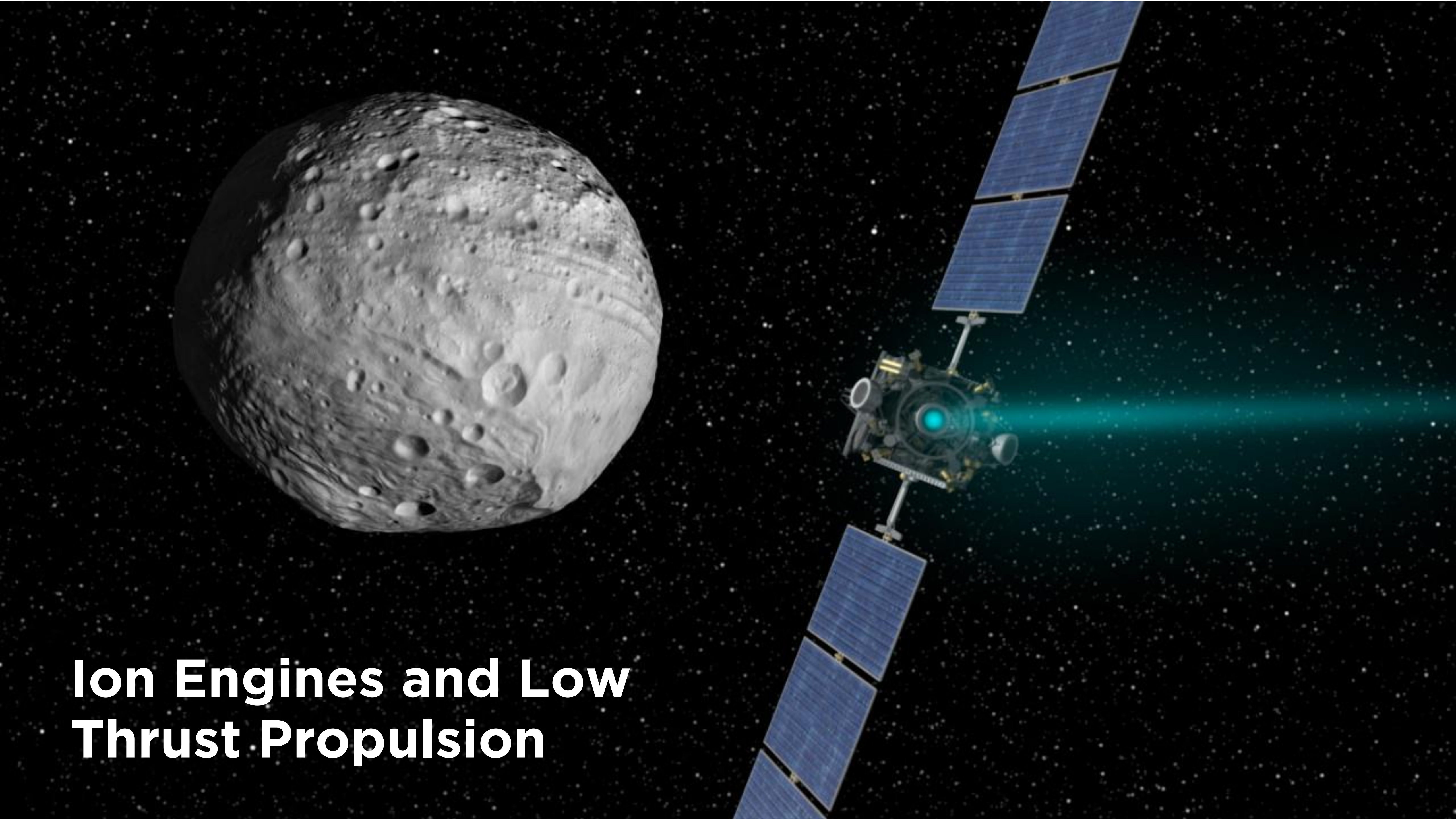
Ion Engines and Low
Thrust Propulsion

Ion Engines Propellant Mass

- As we saw in the previous lecture, ion engines directly accelerate charged atoms or ions.

- Two variants exist:
    - Those based on metals such as Cesium or Mercury which have low ionisation potential and present contamination problems due to the toxicity of these metals.

    - Those based on non-reactive inert gases such as Helium, Argon or Xenon. They are harder to ionise and more benign chemically (ions are not inert).

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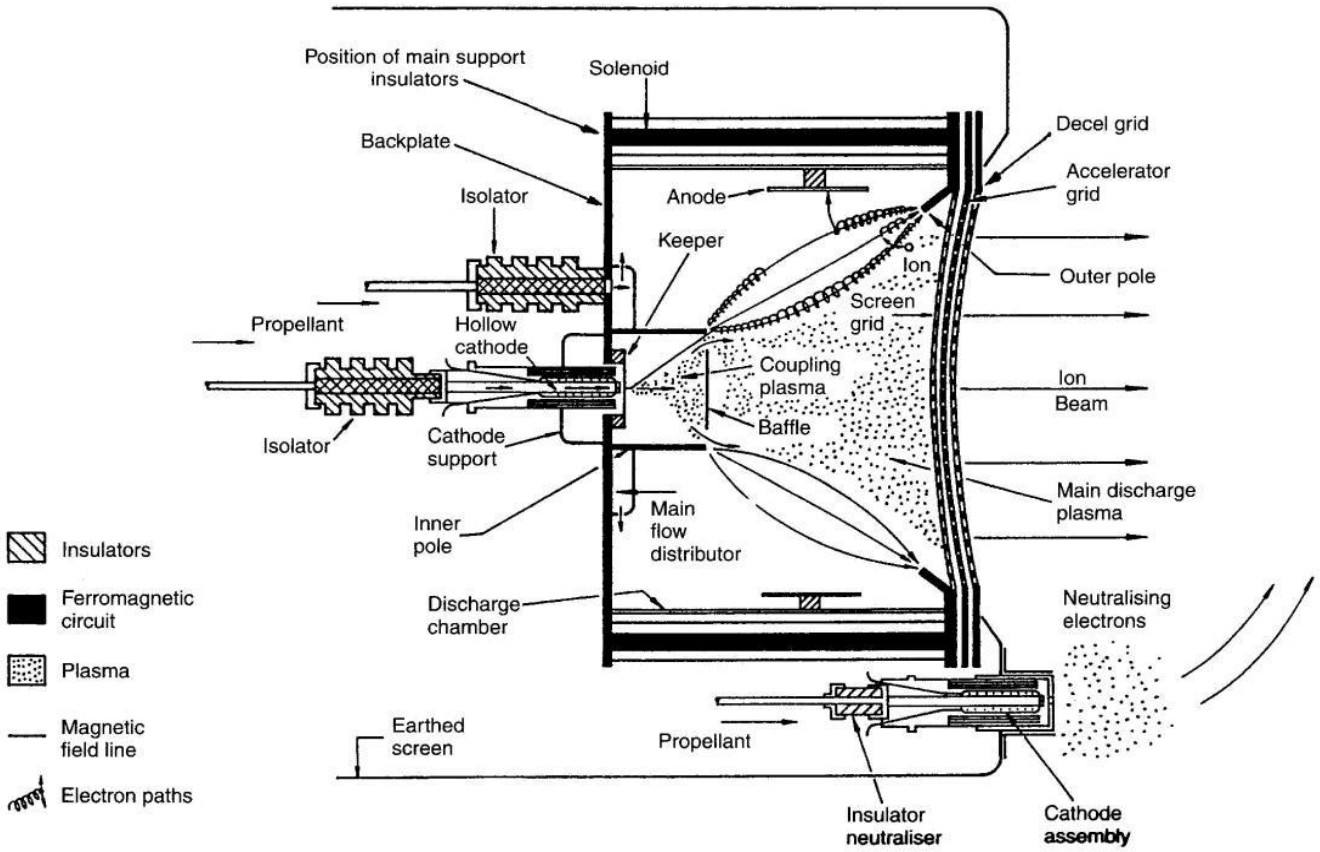
The Functioning of Ion Engines

- The main challenge with ion engines is the very low thrusts they produce.
- It is also important to neutralise the ions once they are ejected by injecting electrons in the exhaust flow.
- Technically, we want to maximise efficiency by converting atoms to ions as effectively as possible while minimising electrode erosion and poisoning (maximise motor life)..



Ion Engines Performance

- Under DC electrostatic acceleration, exhaust velocity v_e in m/s can be calculated as follows:

$$\frac{mv_e^2}{2} = neV$$

- with m the mass of an ion: $A * 1.66 * 10^{-27}$kg and A the atomic weight of the ion.
- e the mass of an electron: $1.6 * 10^{-19}$kg.
- n is the number of electrons removed or the ionisation potential.
- V is the potential difference or voltage.

Examples:

- For singly ionised mercury: V = 10kV, A=200.6, $v_e = 9.81.10^4 \frac{m}{s},$ SI = $10^4\ s$
- For doubly ionised helium: V = 10kV, A=4.002, $v_e = 9.83.10^5\ m/s$, SI = $10^5\ s$

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Gravity Field and Steady-State Ocean Circulation Explorer (GOCE)

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GOCE

- Launched 17th March 2009.

- 5m long, 1100kg, 1m^2 cross sectional are and symmetrical along flight direction to keep aerodynamic drag and torques to minimum.

- Orbits at 260km (very low) to sense Earth's gravitational field.

- Equipped with a 20mN thrust ion engine developed by Qinetiq to counteract atmospheric drag.

- No moving parts as the whole spacecraft is a sensing device.

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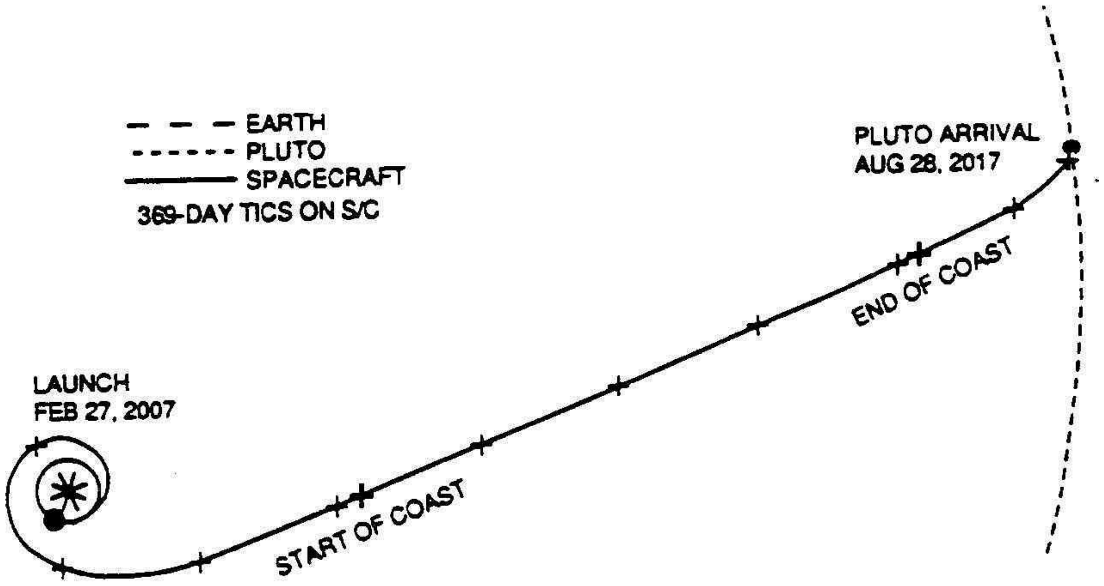
Low Thrust Trajectories

- Solar sails and electric propulsion share the same property of low thrust which can build up over time to a bigger impulse.

- This requires new types of calculations as usual assumptions of immediate thrust impulse are now wrong.

- Usually use direct numerical computations.



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