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P6_3 Crashing Into The Sun

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Abstract

During an episode of the popular BBC science fiction show Doctor Who, the Doctor and his companion Martha answer a distress signal for a ship that's due to crash into the Sun in 42 minutes. During this episode, Martha ends up in a Jettison Escape Pod that detaches from the craft with 17 minutes to go before the collision. At 12 minutes to go, the Doctor activates a magnetic clamp that attracts the pod back to the craft. We calculate the magnetic field strength needed for this and the feasibility given the distances. The magnetic field strength is found to be 0.46 T, which is a feasible magnetic field strength.

Introduction

In the Doctor Who episode called '42', Martha is jettisoned from the main craft on a collision course with the Sun. The Doctor then activates a magnetic clamp to attract the pod back to the ship. We will investigate the magnetic field strength that would be required and the feasibility of this feat. We approximate the spacecraft crashing towards the Sun to have a similar velocity to NASA's fastest space probe, the Parker Solar Mission, at $430,000$ mph (1.9×10^5 ms^{-1}) [?].
We also assume the jettison escape pod has a mass similar to that of a small car, at 1000 kg [?], and the same charge as the Sun at 77 C [?]. We will also assume that it is travelling at the same constant velocity as the falling craft and has no lateral velocity, hence is on a direct collision course with the Sun.

Theory

Given the maximum velocity of the spacecraft and the time at which the escape pod is released, the distance, s, of the craft from the Sun is calculated to be 1.9×10^8 m by:

$$s = vt \tag{1}$$

Where the time, t, is 17 minutes (1020 s) and the velocity, v, is 1.9×10^5 ms^{-1}.

At such a short distance, evidently the spacecraft would crash into the Sun. However, we discuss the feasibility of pulling an escape pod back before it crashes and the magnetic field strength required.

The escape pod falls towards the Sun for 5 minutes before the Doctor activates the magnetic clamp.

Using Eq. (1), we can find the distance of the escape pod from the Sun at 12 minutes (720 s) to go. This gives a value of 1.4×10^8 m.

Using Eq. (2), we can calculate to gravitational force, F_g , between the escape pod and the Sun at 12 minutes before the crash.

$$F_g = \frac{G\,M\,m_{ep}}{r^2} \tag{2}$$

Where G is the gravitational constant (6.673×10^{-11} Nm^{2}kg^{-2}), M is the mass of the Sun (1.989×10^{30} kg) [?], m_{ep} is the mass of the escape pod (1000 kg), and r is the separation between the two (1.4×10^8 m).

F_g is calculated to be 6.8×10^6 N. Hence, a minimum of an equal and opposite magnetic force, F_B, must be applied. Using Eq. (3) we can work out the magnetic field strength needed for this.

$$B = \frac{F_B}{q\,v} \tag{3}$$

Where B is the magnetic field strength, F_B is the force, q is the charge (77 C) and v is the velocity (1.9×10^5 ms^{-1}). This gives a magnetic field strength of 0.46 T.

Conclusion

In conclusion we find the magnetic force to be 6.8×10^6 N, leading to a feasible magnetic field strength of 0.46 T. This is analogous to the typical magnetic field strength of a small electromagnet [?]. However, this magnetic force, F_B, is the minimum that must be applied and would result in the escape pod remaining stationary. Hence, in order for the escape pod to be retrieved, a larger magnetic force would be required.

During the Doctor Who episode, the exact distance of the escape pod from the Sun is not known. Hence, we assumed a constant velocity in order to calculate the initial distance from the Sun. If the initial distance had been known, we would have been able to consider the change in acceleration due to the gravitational pull of the Sun. We hypothesise this would result in a larger magnetic field strength needed to retrieve the pod.

References

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