



FINNISH METEOROLOGICAL INSTITUTE

# **Electric Sail Propulsion**

***A new concept for exploiting solar wind momentum***

***ESA Contracts Final Presentation Days, 20 Feb 2004, ESTEC***

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# Exploit solar wind for propulsion?

## Magnetic propulsion

- Magnetic field forms obstacle for solar wind
- Discussed in another presentation today (“eMPii” project)

## Solid obstacle

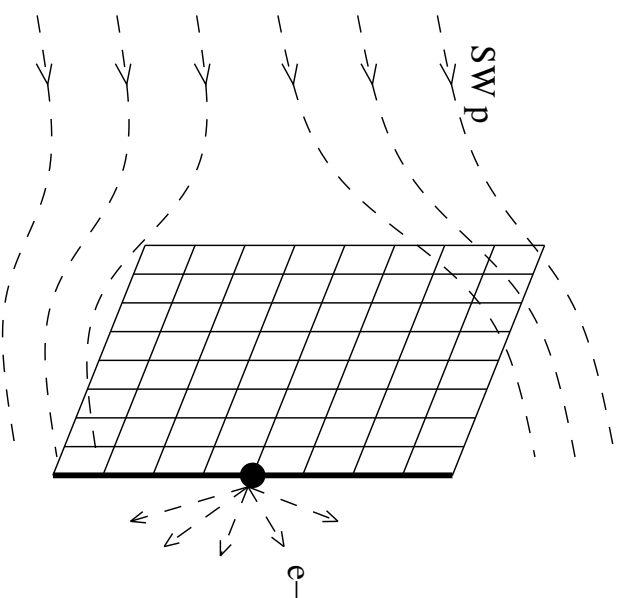
- Solar radiation pressure 5000 times larger than solar wind pressure, so this would be just solar sail

## Electric sail?

- Not only magnetic field affects plasma, also electric field does



# IDEA



- Wire mesh kept at positive potential (some kilovolts)  
⇒ solar wind protons repelled
- Few metre mesh spacing, size tens or hundreds of kilometres
- Few micrometre wire thickness
- Electrons “pumped” out e.g. with electron gun/guns



# Tentative theoretical performance

L	2r	m	a	$v_{\text{final}}$	P	$P_{\text{wire}}/P$
30 km	10 $\mu\text{m}$	250 kg	$7 \times 10^{-3} \text{ m s}^{-2}$	46 km/s	80 W	0.06%
30 km	5 $\mu\text{m}$	63 kg	$0.027 \text{ m s}^{-2}$	91 km/s	40 W	0.11%
60 km	2.5 $\mu\text{m}$	63 kg	$0.11 \text{ m s}^{-2}$	183 km/s	80 W	1%
200 km	2.5 $\mu\text{m}$	700 kg	$0.11 \text{ m s}^{-2}$	183 km/s	1 kW	10%

Removing electrons does not take too much power unless system size is really huge (> 200 – 500 km).

Comparison with solar sail: SW dynamic pressure is  $\sim 5000$  times smaller than radiation pressure. But this is more than compensated by the fact that a wire mesh is, per unit area, much more lightweight than a solid surface (if both have similar thickness and material, say).

**If solar sail is feasible, perhaps electric sail is, too!**



# Is it feasible?

What about deployment?

- Take technology from solar sails, but scale everything bigger and thinner (thin sheet replaced by wire mesh)
- (Of course, no one has yet built a serious solar sail either...)

What about electron gun?

- Needs to be studied, but should not be big problem

Are solar wind protons really repelled?

- Should be studied with e.g. 2-D plasma simulation
- Likewise, needed potential and mesh spacing should be determined in different solar wind conditions from the simulation
- Electron thermal current from plasma to wire should be estimated more accurately



# Conclusions

*Electric sail might work.*

*No magnetic field or exotic technology required.*

*Technology sharing with solar sails.*

*As in all solar wind based methods: solar wind varies, thus navigation not easy, best suited for missions without fixed target.*