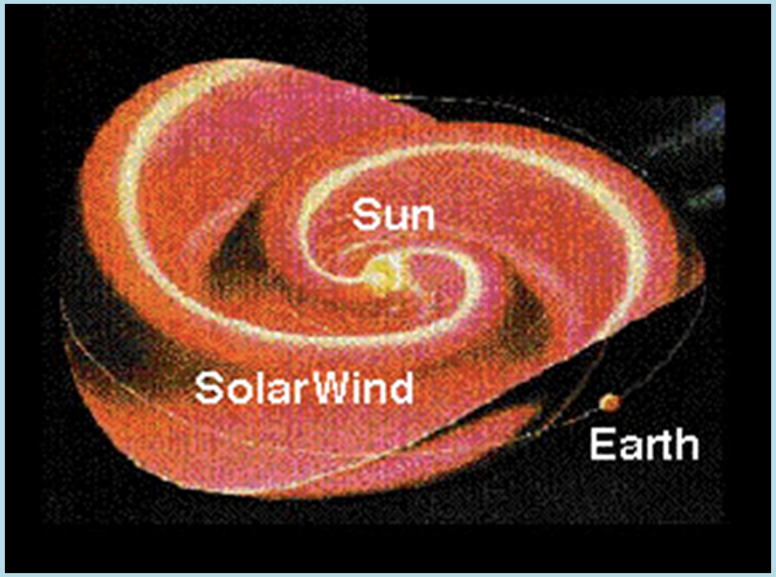
Solar Winds: “Power at a Distance”

By: Jesse Arnold

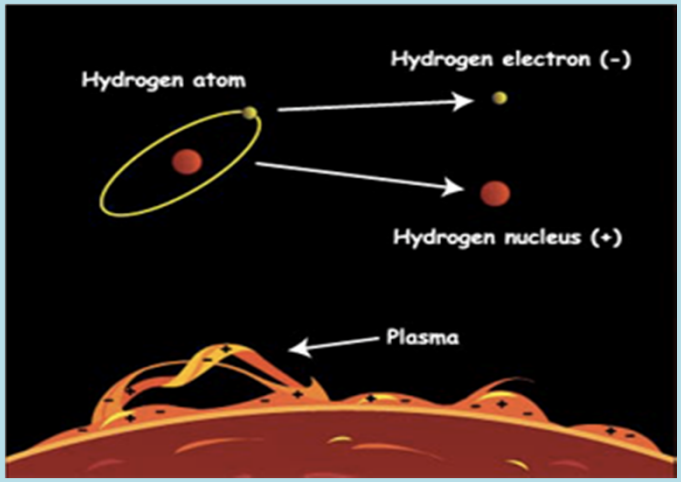
What is Solar Wind

- The suns outermost layer (the corona) can reach temperatures upward of 2 million degrees Celsius.
  - At these levels the suns gravity cannot contain all these rapidly moving particles and they stream away from the star.
  - The sun expels over 1 million tons of matter into space every second.



- Solar winds are the streams of highly ionized plasma atoms and charged particles .

Properties of Solar Winds



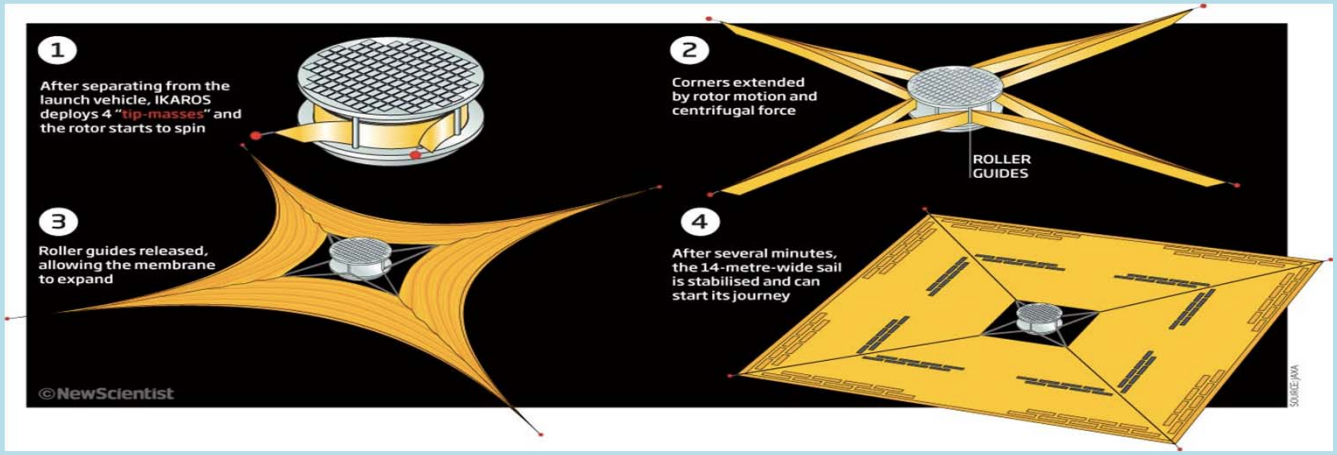
- At 1 AU distance (149,597,871 kilometers) solar wind is composed of :
  - 95% Hydrogen
  - 4% Helium
  - 1% various other materials (carbon,nitrogn,silicon,iron..etc.)
- These atoms, known as plasma, are positive ions have lost electrons from the suns extreme heat.
- Therefore; solar wind is a fast moving collection of these positive ions and their lost electrons.
  - 96% protons and 4% He+ ions by mass.
  - It also contains and adequate number of electrons to keep charge almost perfectly neutral.

Properties cont.

- Solar winds are described as either fast or slow moving.
  - Fast solar winds originate from corona holes near the suns magnetics poles and are accelerated by the magnetic fields.
    - Wind velocity = 400-800 km sec^-1
    - Proton temp. = 230000 K
    - Electron temp = 100000 K
  - Slow solar winds are emitted around the equatorial region where magnetic fields are not as strong and vary greatly.
    - Wind velocity = 250-400 km sec^-1
    - Proton temp. = 340000 K
    - Electron temp. = 130000 K

Method of Collection

- The main method for harvesting energy from solar winds is by use of a solar sail.
  - This method involves using a long strips of copper wire attached to an ultra thin reflective solar cell.
    - The copper strips can range in lengths from 1000ft to over half a mile
    - The sail material must be very thin, reflective, and resistant to high temperature.

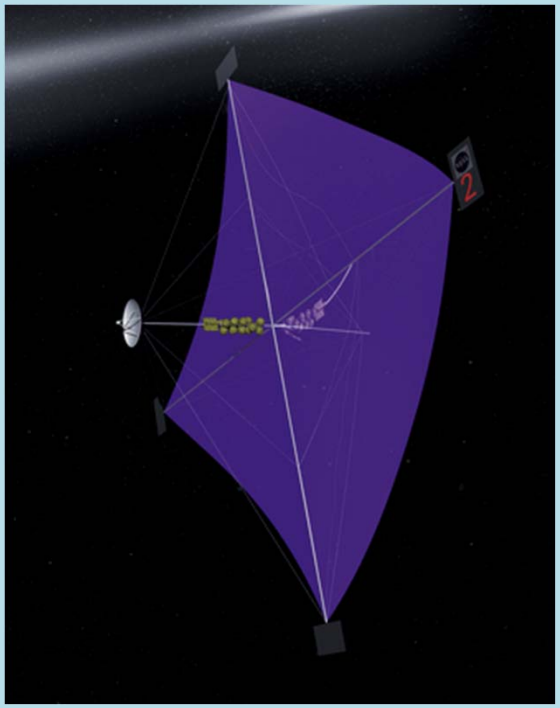


Collection Cont.

- Not a solar cell
  - Electrons already exist in solar winds and do not need to be created/promoted.
  - Just have to collect.
  - Results in a much simpler collection device
- The copper strip produces a magnetic field which will attract and capture the free electrons in the solar winds.
- These particles will then be funnel into a spherical shaped receiver to produce a current.
  - Some of the electricity produced is used to power magnetic field.

Current Uses

- Today there is a lot of interest in using of solar sails for propulsion of space crafts.
  - Less problematic since you do not need to transport the energy for use.
- NASA first performed solar cell research in the 1970s.
  - Materials available at the time were much to heavy to be practical.
  - Its only been in the last decade that solar sail material technology has advanced enough to be useful.

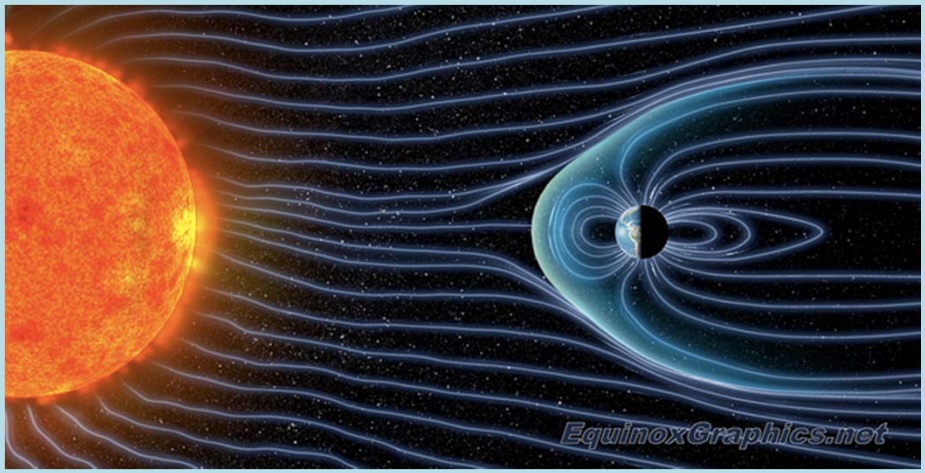


Solar Cells For Propulsion

- In 2014 NASA was set to launch the largest solar sail ever created (Sunjammer Project).
  - The sail measured 124ft on its sides and has a surface area of nearly 13000 ft^2.
  - The sail was made of Kapton and had a thickness of only 5 microns.
  - Weights only 70lbs when folded.
  - Project was canceled due to issues with contractors.
  - Over 21 million spent on the project
- The reflective and lightweight characteristics of the sails are key.
  - Photons will reflect off sails
  - Transfer their momentum to gently push the sail along.
  - Has potential for greater velocity than rockets due to constant transfer of momentum

Limitations

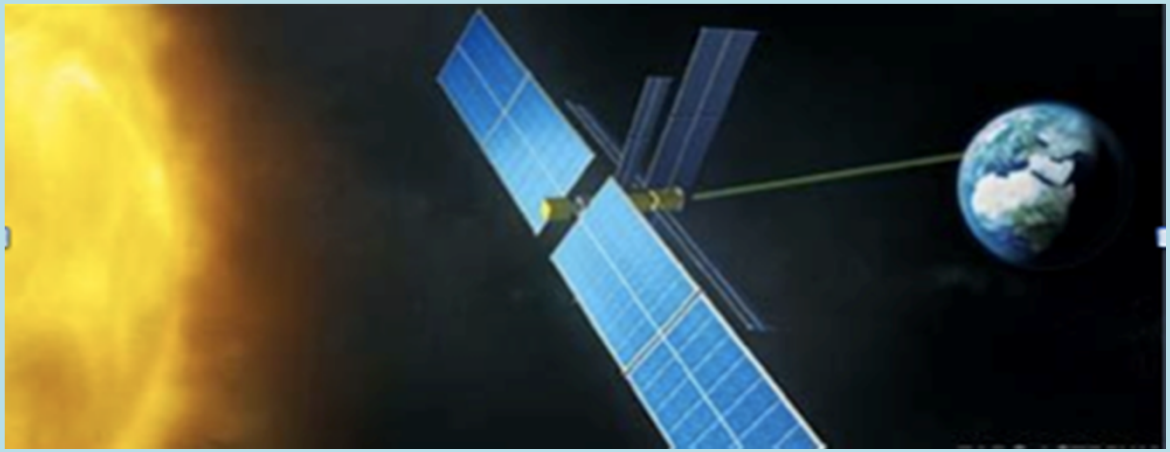
- Earths magnetic field deflects most of the solar winds.
  - More an issue for energy harvesting than for propulsion.
- Collection for solar wind must take place further from earth outside of magnetosphere.
  - Magnetosphere extends 36000 miles into space.
- Distance is always the enemy.



- Using sails to propel large satellites or ships would require a massive amount surface area.

Overcoming the Distance

- The main problem is transporting energy to earth.
  - Energy harvesting satellite would have to be millions of miles from earth to capture a useful amount of energy.
  - Distance is far to vast or any type of cable or physical connection.
- Using lasers would be the only transportation method.
  - However, at these distances even the strongest laser would scatter most of its energy.
  - Huge advancements in optics would need to achieved.



Conclusion

- Using solar winds to help power the earth is a long way from becoming a reality.
  - The technology is still in its infancy
  - The problems associated with transporting energy are massive.
- Using solar cells as a mode of transportation in space is already a viable use for this untapped resource.
  - Much more simplistic process
  - Solved the problem of caring fuel for extended space travel.

- I believe the the distance problem plaguing solar wind energy will be solved not when we figure out how to bring the energy back to earth, but when we start to move into space.

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