Mineral Deposits/Ore Deposits

All mineral deposits form as a result of gradients.

Mechanical/physical gradients:

Velocity, viscosity, gravity, porosity

Chemical potential gradients

Boiling, freezing, phase separation, mixing, fluid/rock interactions

Internal energy content of a planetary body determines whether it is "dead or alive" today

Remember the rock cycle, its processes, and igneous, sedimentary and metamorphic rocks

Remember the dynamic nature of the boundary between ore deposits and mineral deposits

Course Summary Session:

Trajectories, Plasma Propulsion, and Fusion Propulsion

John F Santarius

Lecture 26

Resources from Space

NEEP 533/ Geology 533 / Astronomy 533 / EMA 601

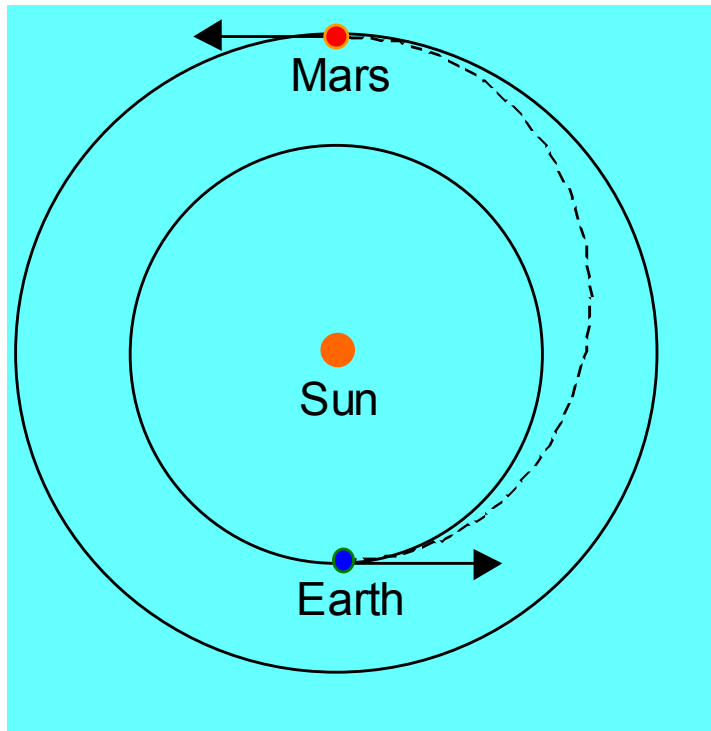
University of Wisconsin

December 14, 2001

Hohmann Transfer Trajectory Can Be Calculated Easily

- Kepler's third law, $T^2 \propto a^3$, can be used to calculate the time required to traverse a Hohmann trajectory.

$$\frac{T_1}{T_2} = \left(\frac{a_1}{a_2}\right)^{3/2}$$



- Earth-Mars Hohmann trajectory

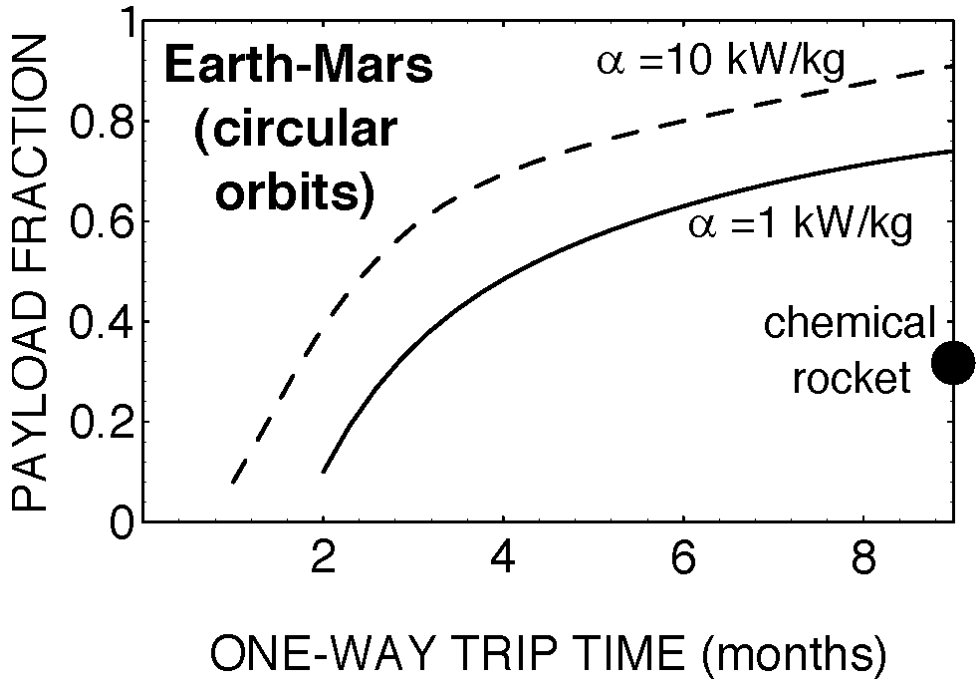
a = (1 AU + 1.5 AU)/2 = 1.25 AU

$T = 0.5\ (a / 1\ \text{AU})^{3/2}$ years
= ~0.7 years = ~8.4 months

Efficient Solar-System Travel Requires High-Exhaust-Velocity Propulsion

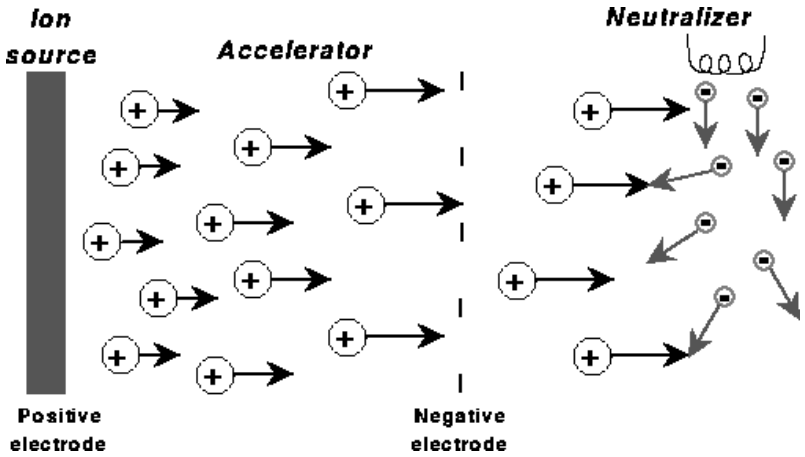
- Electric power can be used to drive high-exhaust-velocity plasma or ion thrusters, or fusion plasmas can be directly exhausted.
  - Allows fast trip times or large payload fractions for long-range missions.
- Uses relatively small amounts of propellant, reducing total mass.

Fusion rocket
($\alpha \equiv$ *specific power*)

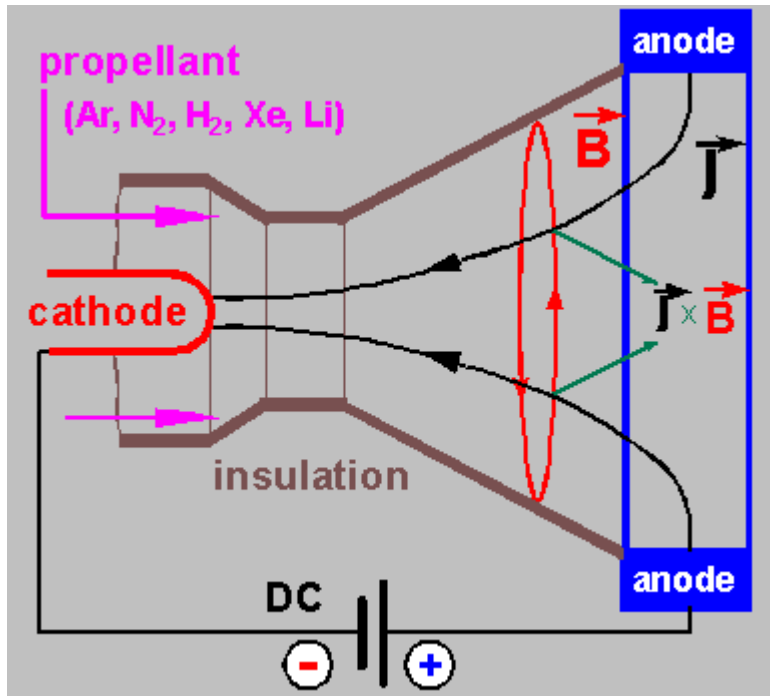


Plasma Thrusters Give High Exhaust Velocity

Electrostatic thruster

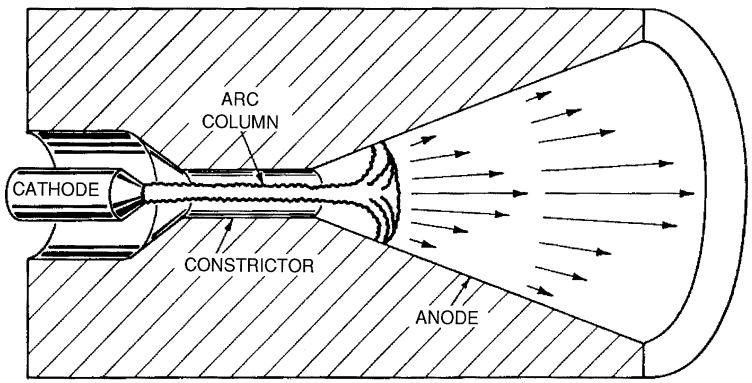


Electrodynamic thruster



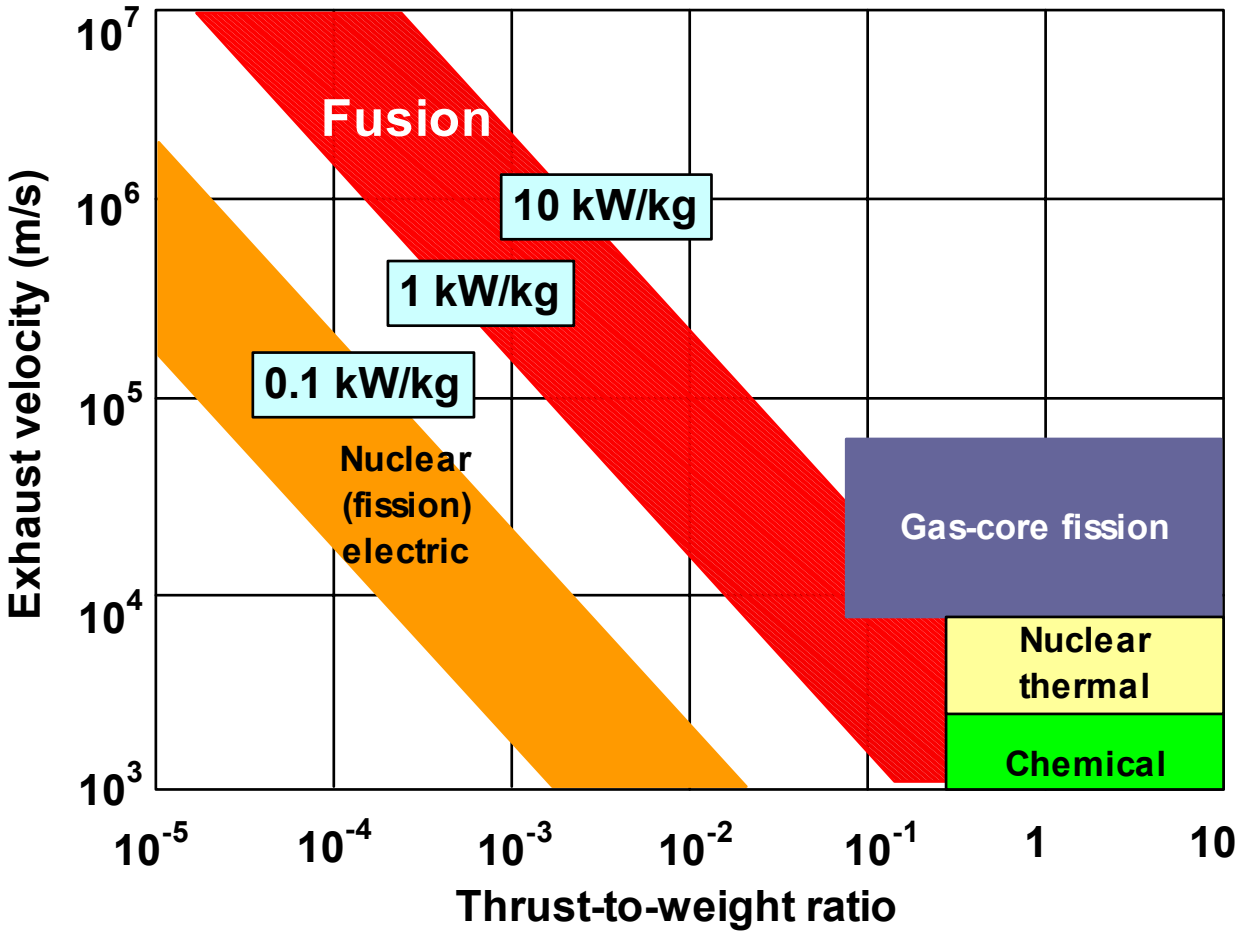
From University of Stuttgart's web page:
www.irs.uni-stuttgart.de/RESEARCH/EL_PROP/e_el_prop.html

Electrothermal thruster

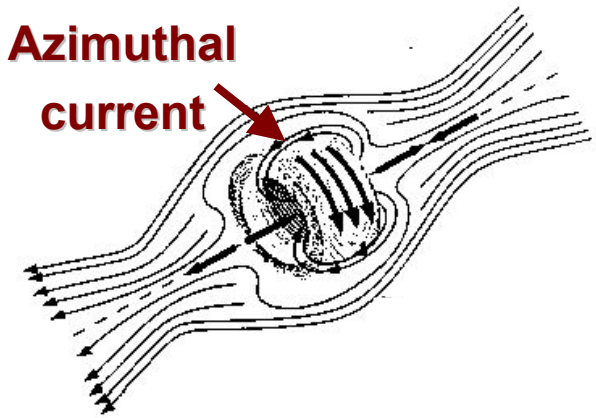


From Robert Jahn,
Physics of Electric Propulsion (1968)

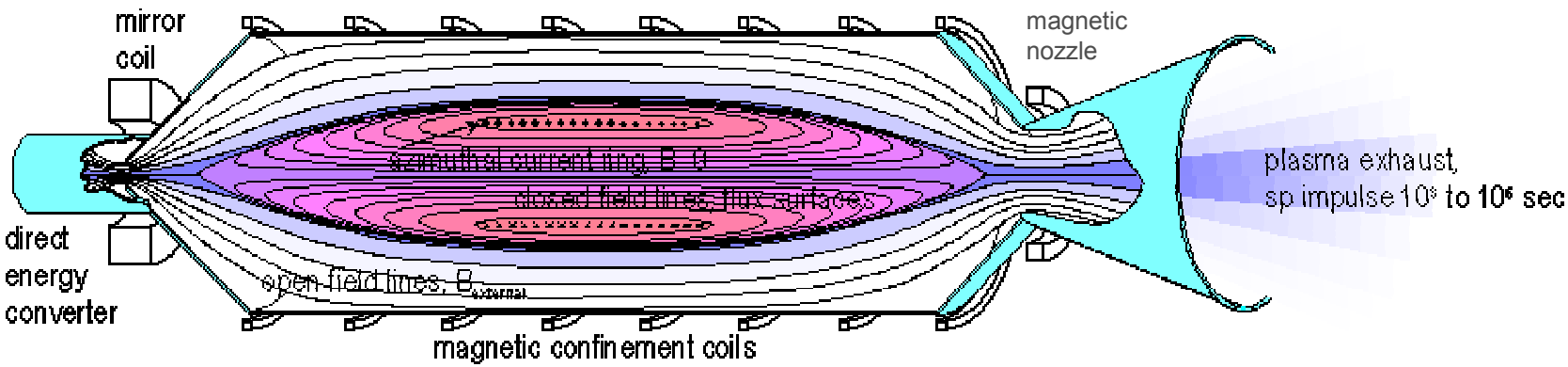
D-^{3}He Fusion Will Provide Capabilities Not Available from Other Propulsion Options



Field-Reversed Configurations (FRC) Would Be Attractive for Space Applications



- High $\beta \equiv P_{plasma}/P_{B\text{-}field}$
- Linear external B field
- Cylindrical geometry
- RMF current drive



FRC as Power Source and Ion Engine for High Energy Space Missions

From Univ. of Washington web page for the Star Thrust Experiment (STX): www.aa.washington.edu/AERP/RPPL/STX.html

What I Hope You Remember in 2020

Professor G. L. Kulcinski

December 14, 2001

Points to Remember!

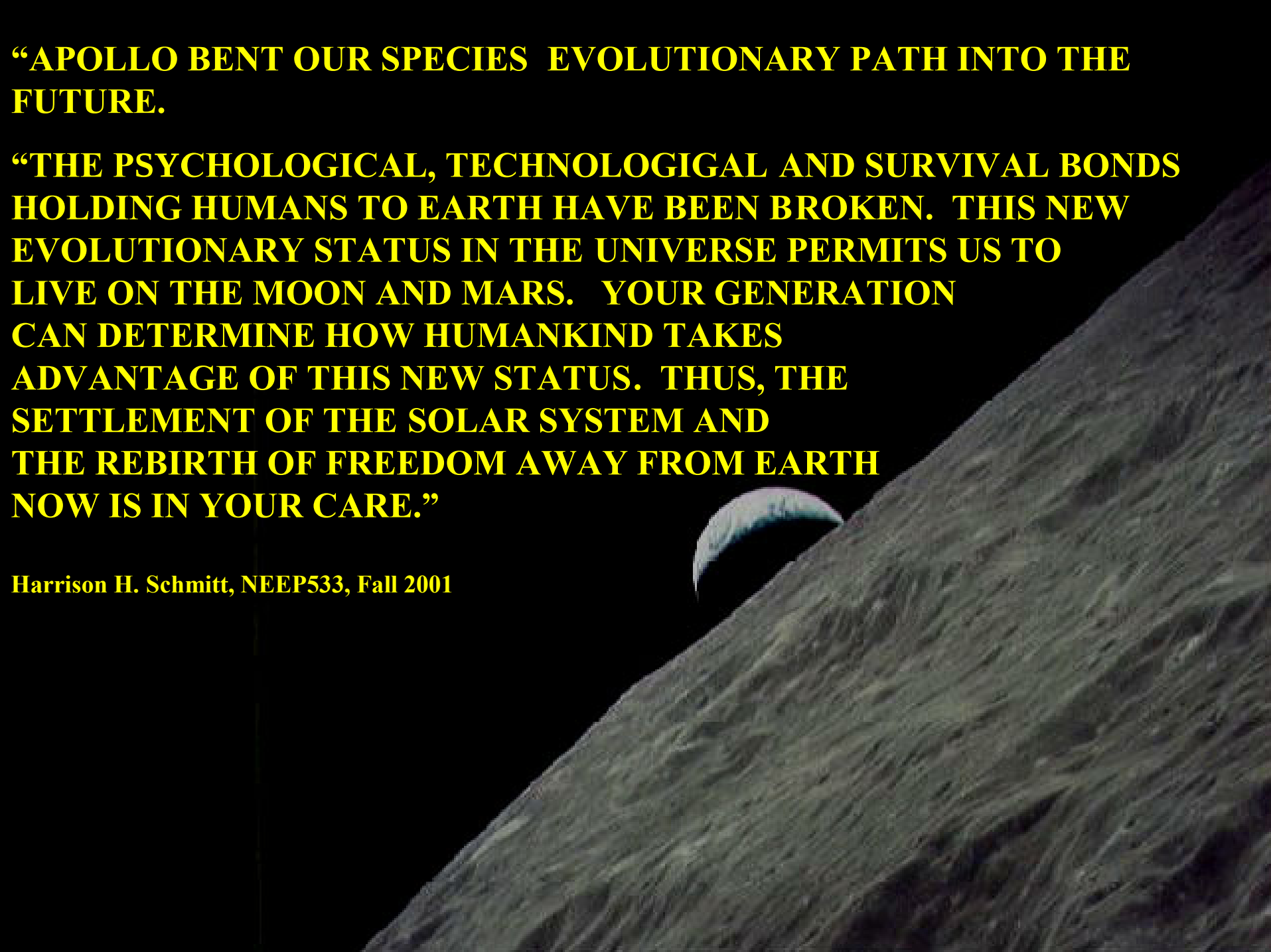
- Expand Your Time Horizons
  - *Serious worldwide energy problems will be encountered when you are 45-50 (when your children are in college or starting their careers)*
- "There's Gold in Them Thar Hills!"
  - *The existence of 1 million tonnes of ^{3}He on the Moon has been established (and we know how to get it!)*
- Solar Wind Volatiles Will Be Enabling Resources for Future Space Exploration
- It is Possible to Think About Nuclear Energy Without Nuclear Waste!
- Consider the "Net" Environmental Impact of Your Actions
  - *Will the use of a resource produce more benefits than the environmental cost of obtaining it?*

RETURN TO THE MOON

THIS TIME WE STAY

SECOND ANNUAL LUNAR DEVELOPMENT CONFERENCE JULY 20-21, 2000 SPACE FRONTIER FOUNDATION ARTWORK CREATED FOR SPACE FRONTIER FOUNDATION BY MARK MAXWELL

Resources From Space Class – Fall 2001



“APOLLO BENT OUR SPECIES EVOLUTIONARY PATH INTO THE FUTURE.

“THE PSYCHOLOGICAL, TECHNOLOGIGAL AND SURVIVAL BONDS HOLDING HUMANS TO EARTH HAVE BEEN BROKEN. THIS NEW EVOLUTIONARY STATUS IN THE UNIVERSE PERMITS US TO LIVE ON THE MOON AND MARS. YOUR GENERATION CAN DETERMINE HOW HUMANKIND TAKES ADVANTAGE OF THIS NEW STATUS. THUS, THE SETTLEMENT OF THE SOLAR SYSTEM AND THE REBIRTH OF FREEDOM AWAY FROM EARTH NOW IS IN YOUR CARE.”

Harrison H. Schmitt, NEEP533, Fall 2001