Louisiana State University

Center for Computation and Technology

RAMJET ROCKET ENGINE

Presented by:
Florin Mingireanu

Advisor: dr. Edward Seidel

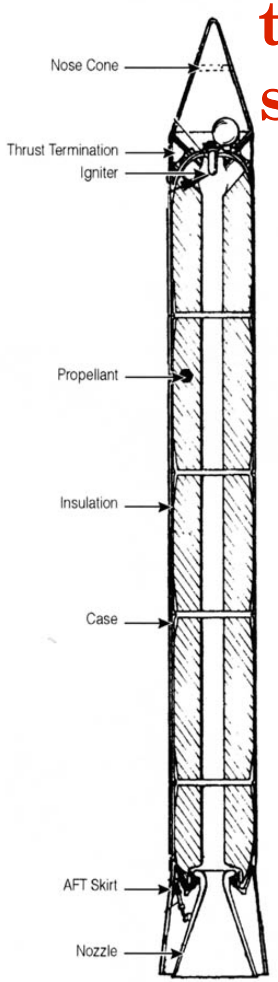
Aerospace historic moments

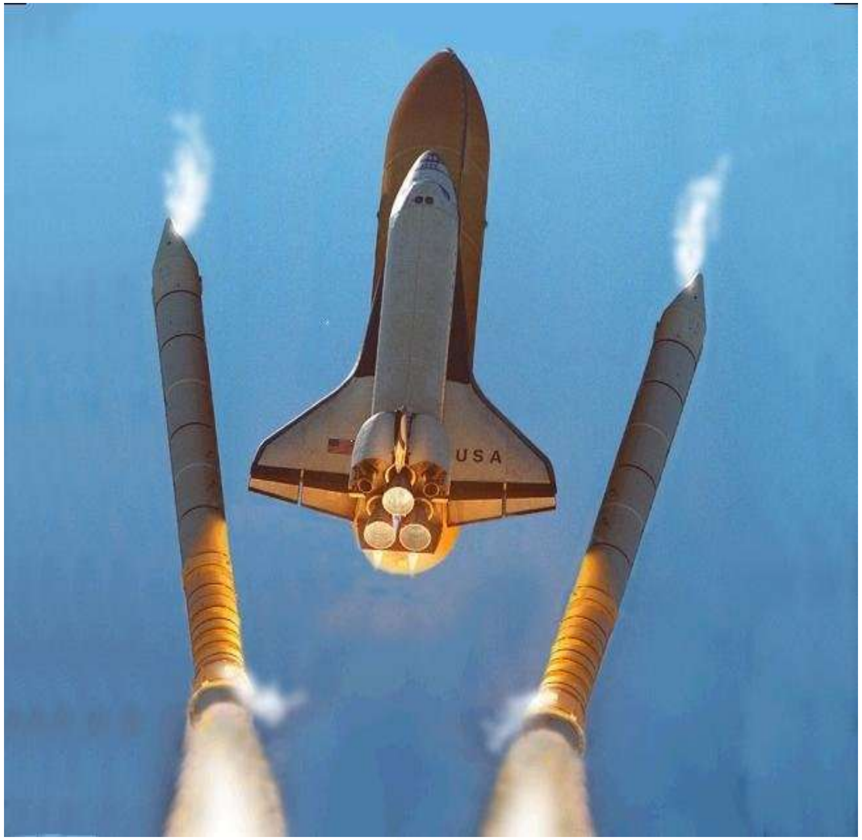
- first century A.D. chinese army launches gun powder rockets
- Around 1800 Constantin Tiolkovski creates the theory of interplanetary flight
- 1910-1940: researches in both solid and liquid rocket engines-main concern: optimization of burning chamber and injection of the fuel.
- Second world war: Herman Oberth and Werner Von Braun work on rockets for german army. First succesful liquid rocket engines used in military applications

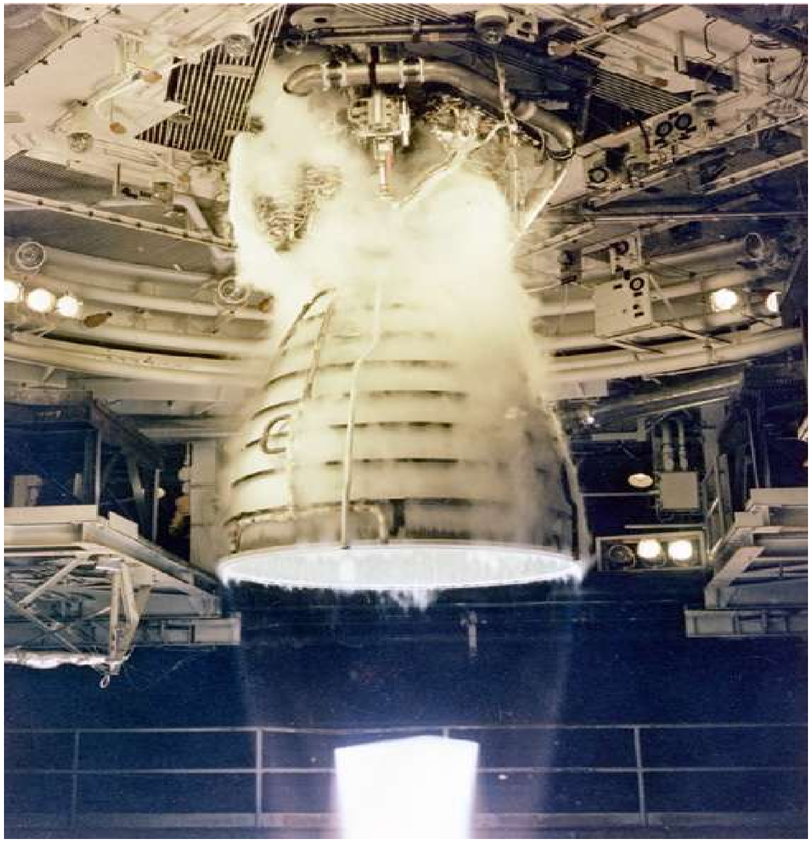
ROCKET TECHNOLOGY TODAY

SOLID ROCKET ENGINES-fuel and oxidizer in the same tank-solid state

LIQUID ROCKET ENGINES-fuel and oxidizer in different tanks-liquid state

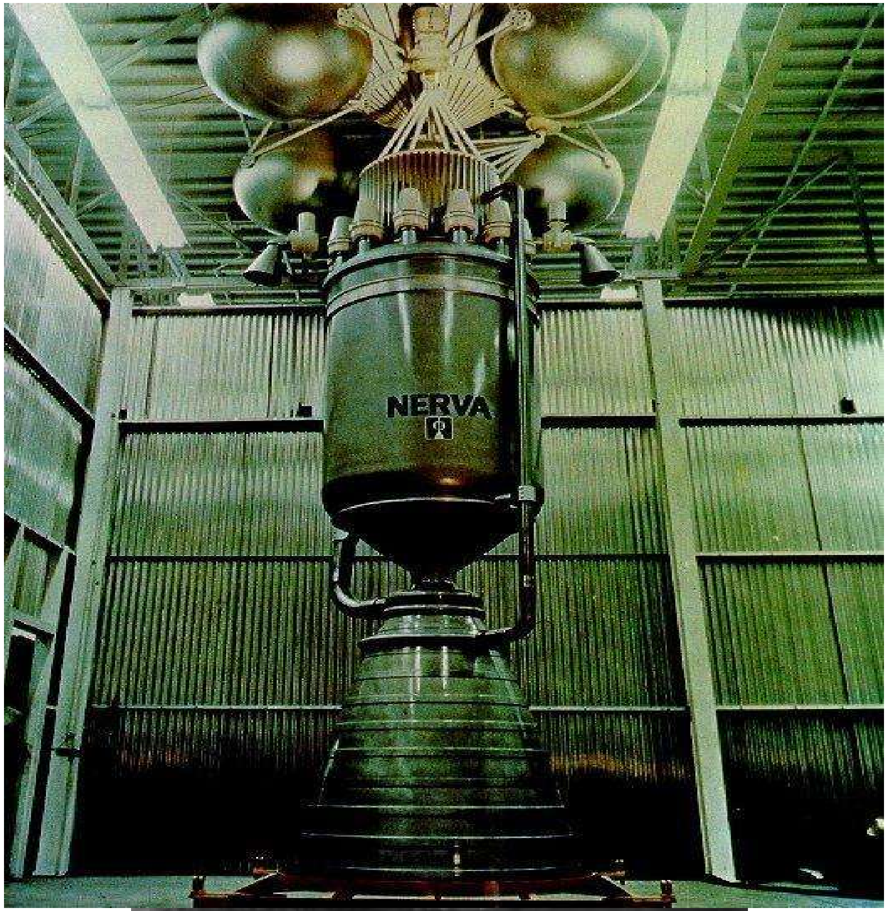


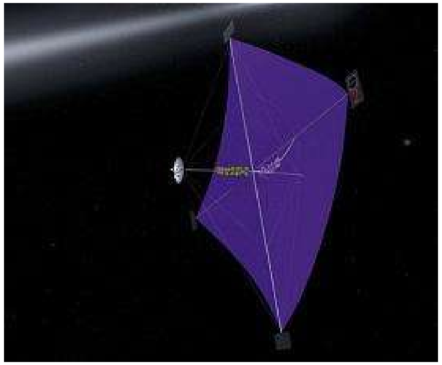




Current Technologies

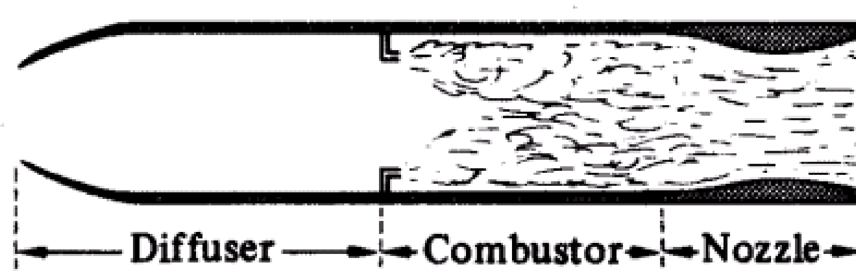
- Ionic engines: low specific impulse, long operation time
- Nuclear rockets:solid, gaseous-studied at Los Alamos
- Solar sail, antimatter rocket, ramjet, casimir engine, MHD engine- currently in concept phase





Initial ramjet concept-how an idea is born

- Analog with water jet-sky
- It absorbs fuel from surrounding medium, accelerate it and evacuates:conservation of momentum $(\vec{p}1)=(\vec{p}2)$
- First design done by germans during WW 2

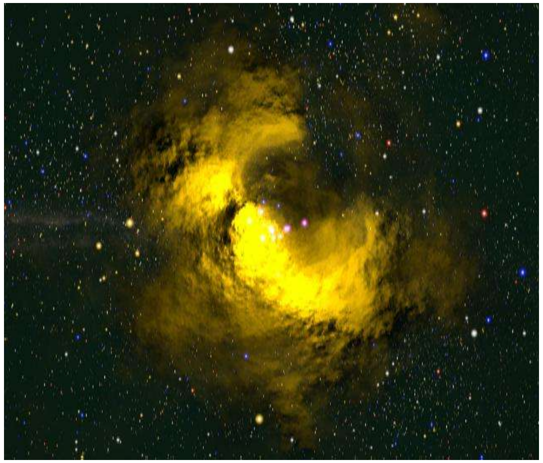


Cosmic clouds

Bok globulae:
T=10K-30K; n=10000 cm-3

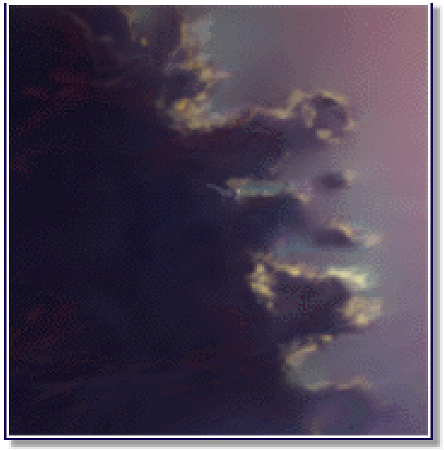
HII regions:
T=60K-80K; n=10e9 cm-3

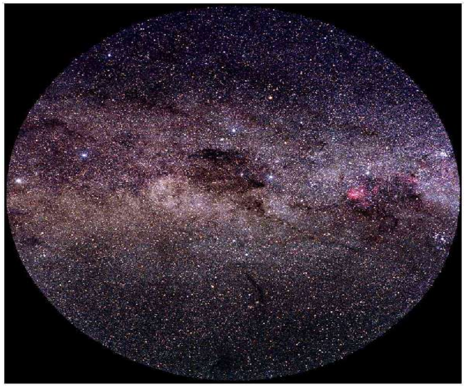
Nebulae
T= 10 K; n=10000 cm-3



Orion Nebula Mosaic HST • WFPC2
PRC95-45a • ST ScI OPO • November 20, 1995
C. R. O'Dell and S. K. Wong (Rice University), NASA

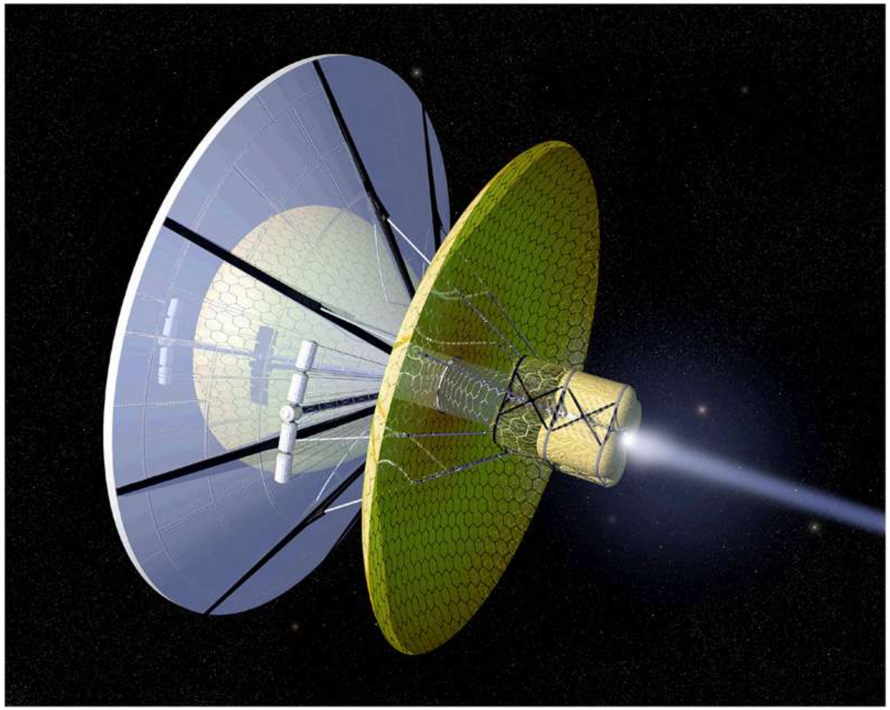
Giant molecular clouds
T=15-50K; n=500-5000 cm





Ramjet based spaceship

- Instead of water/air, use interstellar medium
- Low density, lower accelerations, longer mission times
- High terminal velocities over long time: cumulative effects

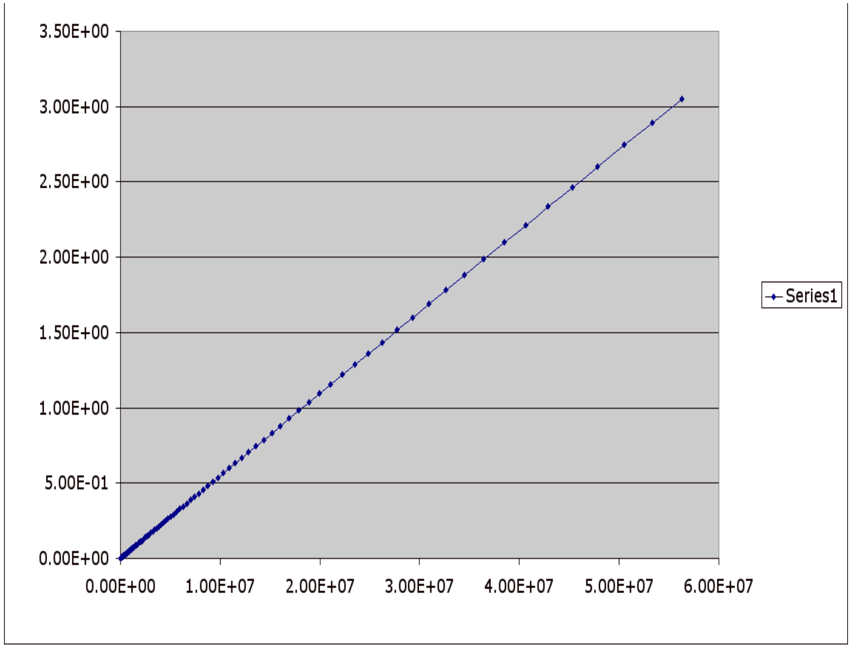


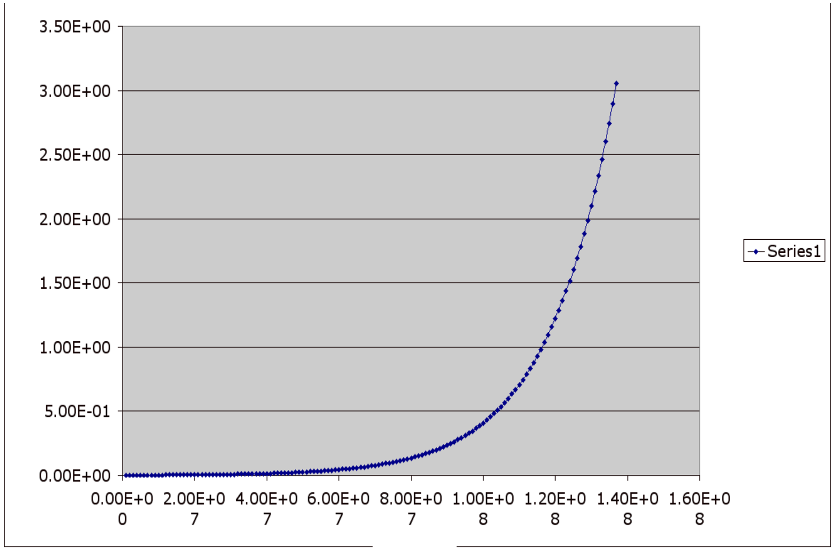
A little about physics of the ramjet

- Reference frame set on the ramjet
- Variation in energy equal with electric energy gained during electric acceleration: $\delta E = eU$
- Non-relativistic case: $\delta E = \delta E_c$
- Relativistic case: $\delta E = \delta E_{total}$ $\quad \delta E_{total} = (m_{final} - m_{initial}) c^2$ $\quad m = f(v) = m_{rest} / \sqrt{(1 - v^2 / c^2)}$
- Conservation of momentum -> speed of the ramjet
- Instant mass flow in the engine: $\delta m = n S v m$

Non-relativistic regime

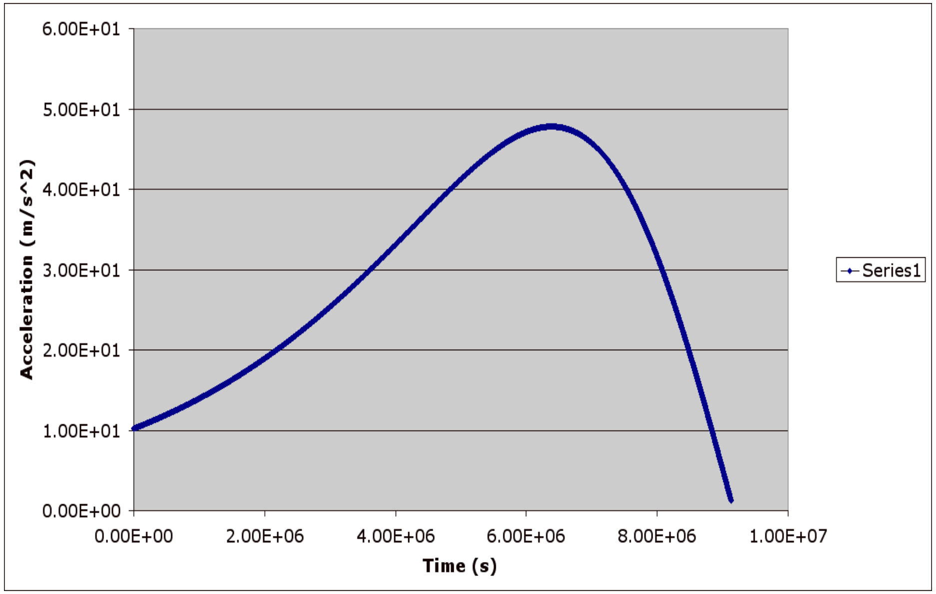
- Movement of interstellar medium reaches relativistic regim
- Ramjet does NOT have relativistic speed (v < 0.2 c)
- Simpler numerical codes: same results as full relativistic codes

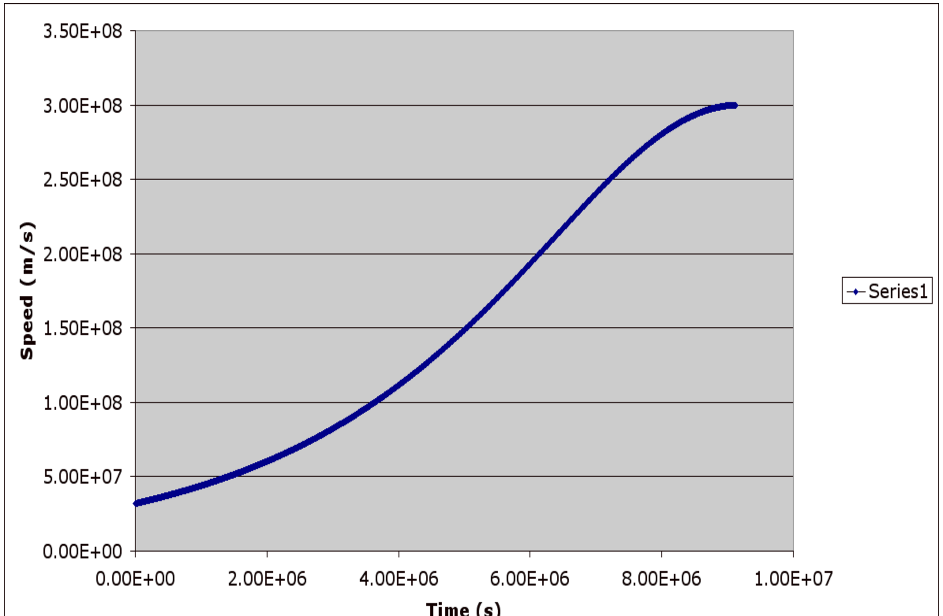




Relativistic regime

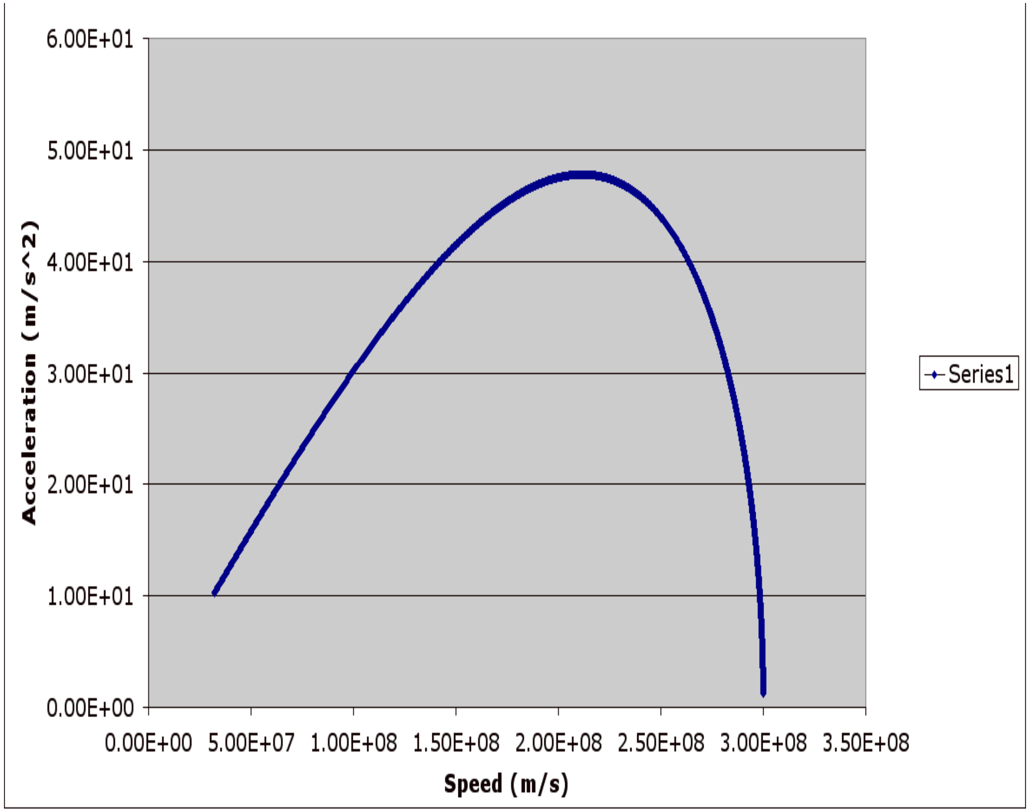
- Relativistic codes both for interstellar medium acceleration and ramjet movement
- Adaptive mesh refirement- multi-grid analysis
- Edge effects more important- critical effects





Relativistic effect

- Low speeds (non-relativistic regim) speed seems to increase unbounded
- High speeds (relativistic regim) acceleration have an inflexion point



Pinch effect and stability

- Charged beam -> electric current -> magnetic field radially symetric
- Value of the magnetic field ~ I/r^2
- Magnetic pressure vs. Boltzmann pressure $pm = B^2/12.75\,;\; pb = nKT$
- Continuity equation: $V_z \rho \gamma R^2 = const$
- stress energy vector $(T^{(\alpha\beta)})_\beta = 0$
- Bernoully relativistic equation
- $(d/dz)\gamma^2 v_z R^2[\rho c^2 + 4p' + B'/(4pi)] + 2r_g/(v^2)_z \gamma^2 v_z R^2(\rho c^2 + 4p' + 2U') + S_{rad} = 0$
- Radial dynamical pressure is of the order of magnetic pressure for linear flows $v_r \ll v_z$

What we accomplished:

1.) We understood what the physical limitation for an interstellar ramjet are

2.) We have obtained estimates of the capabilities of the ramjet

3.) We have opened questions about non-relativistic and relativistic plasma flowing problems

4.) Obtained an integrated numerical model for a simplified engine

5.) Complicated the system by introducing primitive edge effects

TO DO (homework) list:

1.) Analyse in greater the detail the friction in low density region and moderate speeds (non-relativistic regim)

2.) Better understanding of non-uniform rarefied plasma flowing through the engine- what bounday conditions should be met?

3.) Better understanding of edge effects in near relativistic regime

4.) Interaction between materials and interstellar wind- erosion problems?

5.) Better understanding of distribution and composition of interstellar matter inside our Galaxy

Thanks:

- NIAC-USRA: support in developing this idea

- dr. Edward Seidel: discussions on relativity and key notes with general elements

- Center for Computation and Technology: computer acces (computing clusters) and software support- working towards parallel running of relativisitic codes

- Louisiana State University: wonderful research facilities

-and professors for allowing me to skip classes and come to the NIAC conference

THE END