Mach Effects for In-Space Propulsion: *An Interstellar Mission*

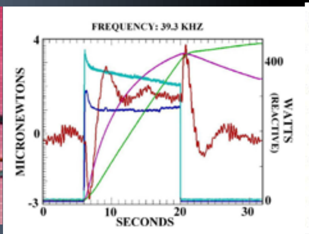
Dr, Heidi Fearn, Dr. José Rodal, Dr. Marshall Eubanks
Dr. Bruce Long, Dr. James F. Woodward, Paul March and Gary C Hudson

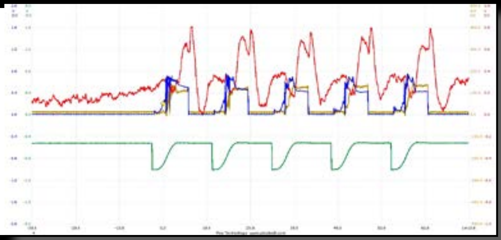
NIAC Study Approach
Three primary tasks are identified:

1. Improve current laboratory-scale devices to provide long duration thrusts for practical propulsion (e.g. chirped pulsed AC)

2. Design and develop power supply and electrical systems to provide feedback and control of the input AC voltage and frequency. This will improve the efficiency of the MEGA drive.

3. Using the best results from steps 1 and 2 above, design a probe to carry 400 kg payload to Proxima Centauri within 20 years, with data to be recorded and transmitted back in 5 additional years. (Close rendezvous with Proxima B.)





Chirped pulses, freq. starts high then drops down to the resonant frequency of the device. Chirp is shown inverted in green. The blue trace is the voltage pulse amplitude. The red trace is the thrust of the device. : Steady force and transients have been confirmed by 3 other labs, Tajmar, TU Dresden, Hathaway Toronto Canada, Buldrini, Austria.

Reference Mission: Can we travel outside our solar system, collect data and send it back to Earth?

Astronomers have discovered a roughly Earth-size alien world around Proxima Centauri, which lies just 4.2 light-years from the solar system.

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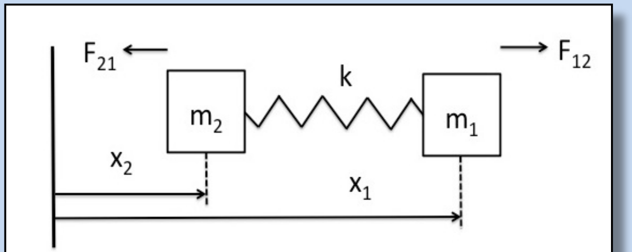

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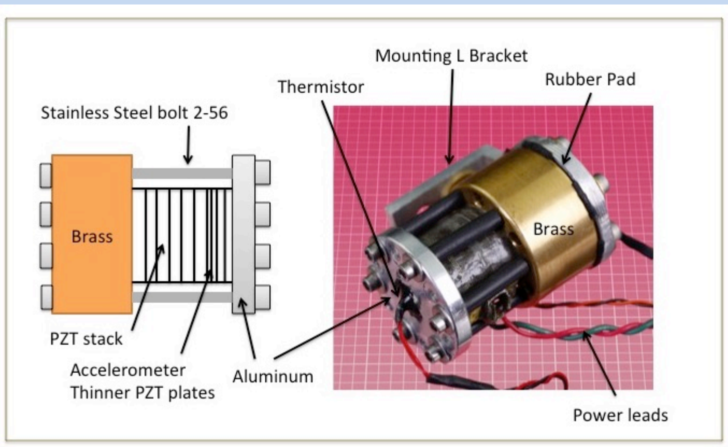

$$m_1\ddot{x}_1 = -k(x_1 - x_2 - L) + F_{12}$$
$$m_2\ddot{x}_2 = +k(x_1 - x_2 - L) + F_{21}$$

adding these equations gives,

$$m_1\ddot{x}_1 + m_2\ddot{x}_2 = -k(x_1 - x_2 - L) + F_{12} + k(x_1 - x_2 - L) + F_{21}$$
$$F_{12} = -F_{21}$$
$$\Rightarrow m_1\ddot{x}_1 + m_2\ddot{x}_2 = 0.$$

The COM of this mass-spring arrangement is given by

$$x_{com} = \left(\frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}\right) .$$

The acceleration of the COM, for masses taken to be constant, is therefore

$$a_{com} = \ddot{x}_{com} = \left(\frac{m_1\ddot{x}_1 + m_2\ddot{x}_2}{m_1 + m_2}\right) = 0$$

$$a_{com} = \frac{1}{2(m_{01} + m_{02})}\left(\frac{\omega^2 F_0}{\omega_0^2 - \omega^2}\right)\left[\frac{\delta m_1}{m_{01}}\cos\phi_1 - \frac{\delta m_2}{m_{02}}\cos\phi_2\right]$$

This result is based on the General Relativity of Einstein plus Wheeler-Feynman type absorber theory (adv./ret. waves) applied to gravitation.

$$\delta m_0 = \frac{1}{4\pi G}\left[\frac{1}{\rho_0 c^2}\frac{\partial P}{\partial t} - \left(\frac{1}{\rho_0 c^2}\right)^2 \frac{P^2}{V}\right]$$

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$$
\begin{aligned}
F &= F_0 \cos(\omega t) \\
m_1(t) &= m_{01} + \delta m_1 \cos(\omega t + \phi_1) \\
\dot{m}_1(t) &= -\omega \delta m_1 \sin(\omega t + \phi_1) \\
\ddot{m}_1(t) &= -\omega^2 \delta m_1 \cos(\omega t + \phi_1)
\end{aligned} \tag{11}
$$

where masses m_{01} , m_{02} and phases ϕ_1 , ϕ_2 are constant. The mass change δm is considered very small. Similar equations to Eq.(11) hold also for m_2 and its derivatives with respect to time. We take for the reduced mass $\mu = \mu_0$ (when the masses do not change) and $\omega = \omega_0 = (k/\mu_0)^{1/2}$. The solution for u(t) is found as follows:

$$
\begin{aligned}
u(t) &= x_1(t) - x_2(t) - L = u_0 \cos(\omega t) = \mathrm{Re}[u_0 e^{i\omega t}] \\
\dot{u} &= i\omega u \\
\ddot{u} &= -\omega^2 u \\
(\omega_0^2 - \omega^2) u_0 &= \frac{F_0}{\mu_0}
\end{aligned} \tag{12}
$$

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$$\ddot{u} = -k\frac{u}{\mu} + \frac{F}{\mu}.$$

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$$u(t) = \left(\frac{F_0}{\omega_0^2 - \omega^2}\right)\frac{\cos(\omega t)}{\mu_0}.$$

$$\dot{p} = \left(\frac{\omega^2 F_0}{\omega_0^2 - \omega^2}\right)\left[\frac{\delta m_1}{m_{01}}\sin(\omega t)\sin(\omega t + \phi_1) - \frac{\delta m_2}{m_{02}}\sin(\omega t)\sin(\omega t + \phi_2)\right]$$

$$\dot{p} = \frac{1}{2}\left(\frac{\omega^2 F_0}{\omega_0^2 - \omega^2}\right)\left[\frac{\delta m_1}{m_{01}}\cos\phi_1 - \frac{\delta m_2}{m_{02}}\cos\phi_2\right] = (m_{01} + m_{02})a_{com}$$

$$\ddot{u} = \ddot{x}_1 - \ddot{x}_2$$

$$m_{01}\ddot{x}_1 + m_{02}\ddot{x}_2 = 0$$

$$a_{com} = \frac{1}{2(m_{01} + m_{02})}\left(\frac{\omega^2 F_0}{\omega_0^2 - \omega^2}\right)\left[\frac{\delta m_1}{m_{01}}\cos\phi_1 - \frac{\delta m_2}{m_{02}}\cos\phi_2\right]$$

$$x_1(t) = \left(\frac{m_{02}}{m_{01} + m_{02}}\right)u(t)$$

$$x_2(t) = -\left(\frac{m_{01}}{m_{01} + m_{02}}\right)u(t)$$

$$\delta m_0 = \frac{1}{4\pi G}\left[\frac{1}{\rho_0 c^2}\frac{\partial P}{\partial t} - \left(\frac{1}{\rho_0 c^2}\right)^2\frac{P^2}{V}\right]$$

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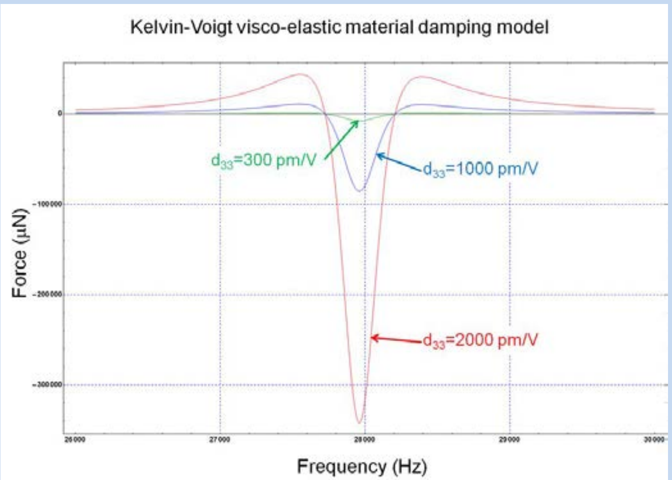

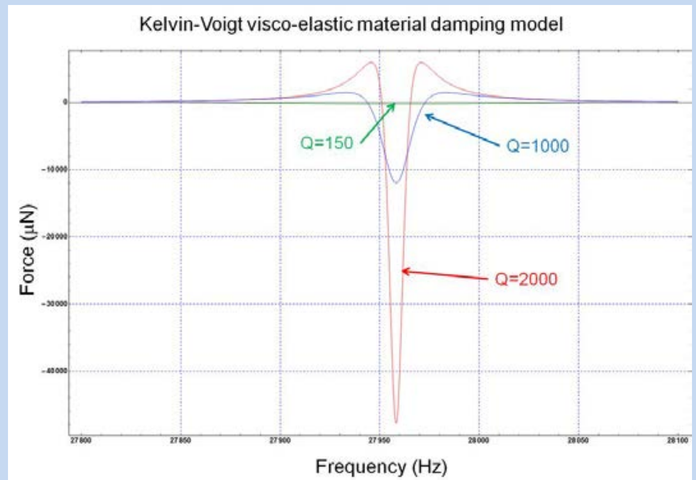

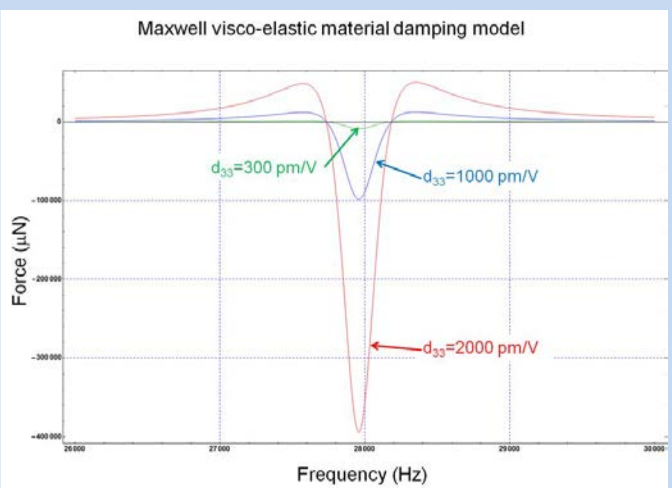

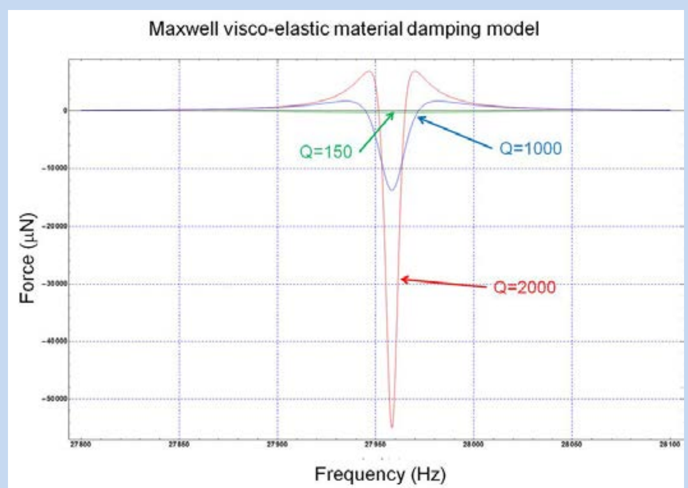

Model by José Rodal:
Exact viscoelastic
Differential eqn.
model-
An earlier, mass spring dashpot type model was used in the Estes Park Advanced Propulsion Workshop, Estes Park, CO Sept.2016. http://ssi.org download.