

ASTROFIZIKA ZA VELIKE KROZ MATEMATIKU ZA MALE

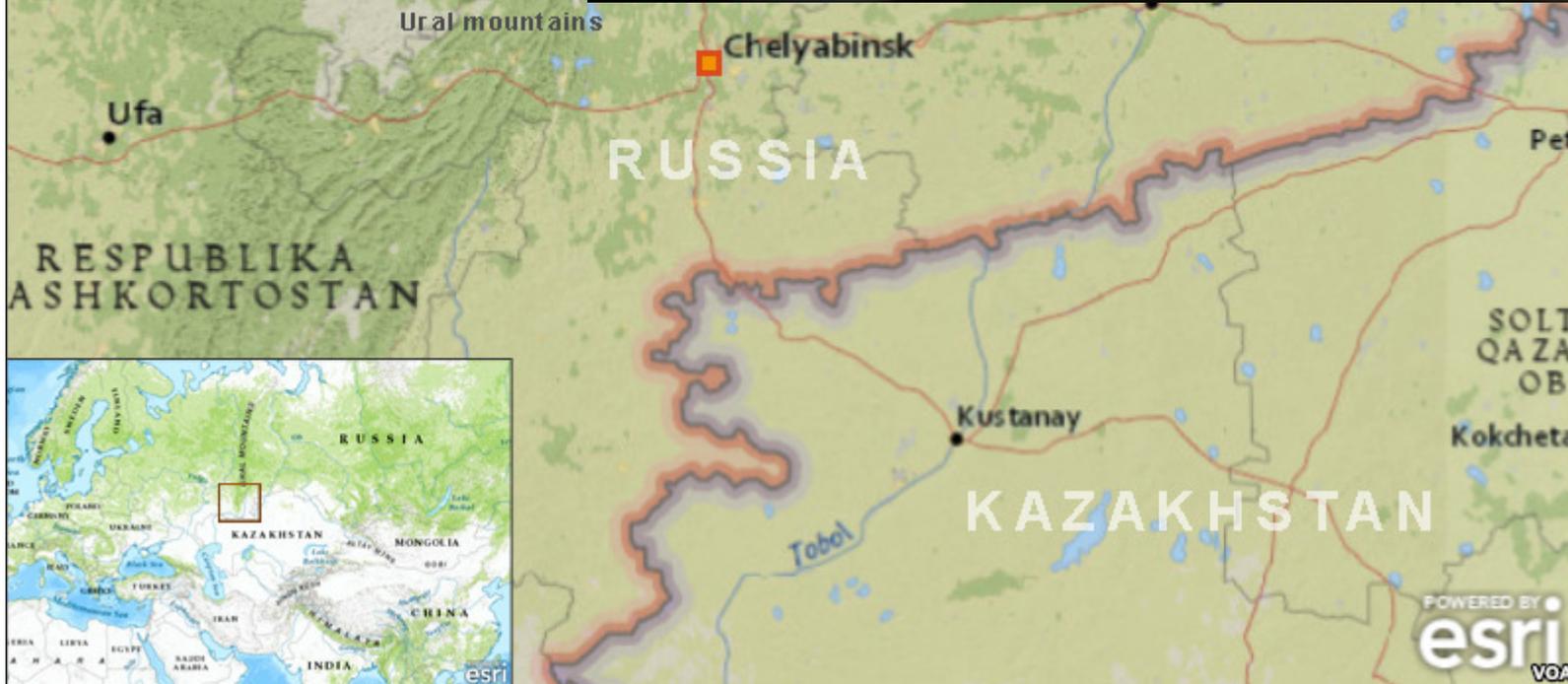
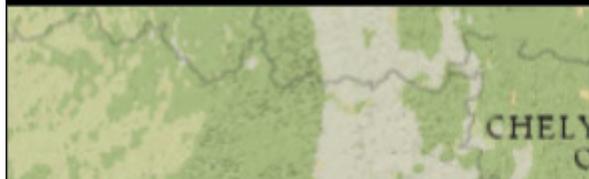
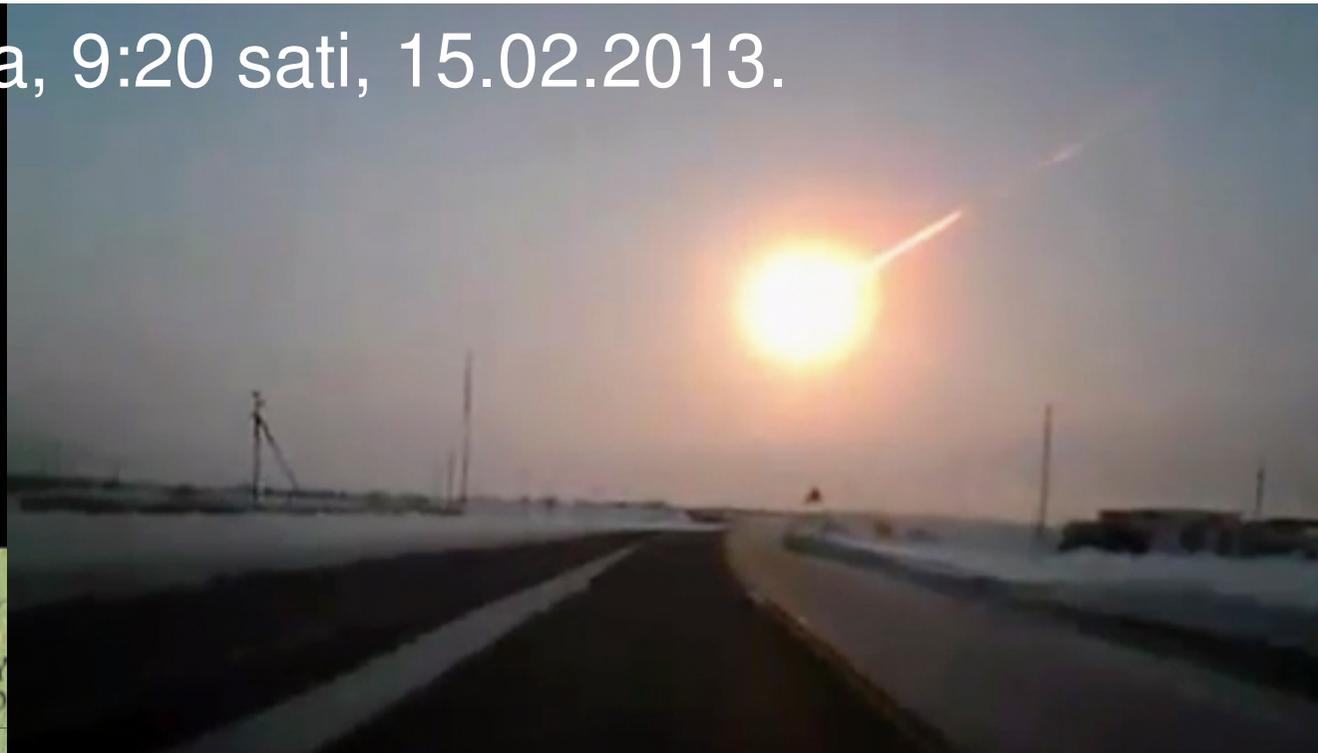
2.dio

Dejan Vinković

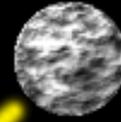
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www.vinkovic.org

Čeljabinsk, Rusija, 9:20 sati, 15.02.2013.



meteoroid
(from asteroids, comets)



brzina $\leq 72\text{km/s}$

visina: tipični meteori = 70-100km (~milijun puta rjeđa atmosfera)

spori meteori = ~20-70km

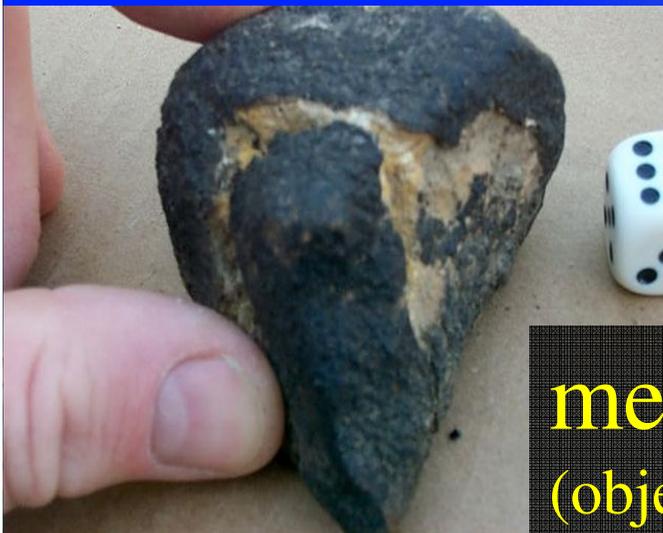
veličina: tipični = 0.05mm-20cm

meteor

(sudar sa zemljinom
atmosferom)

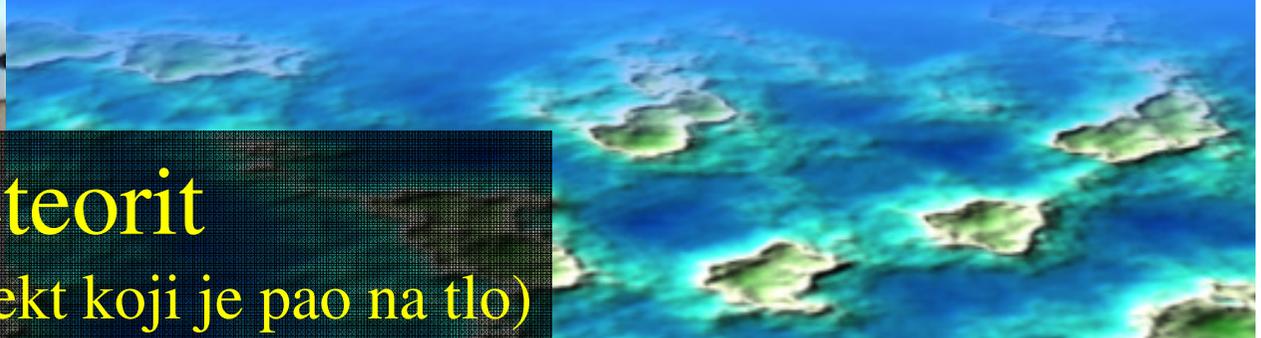
vatrena kugla

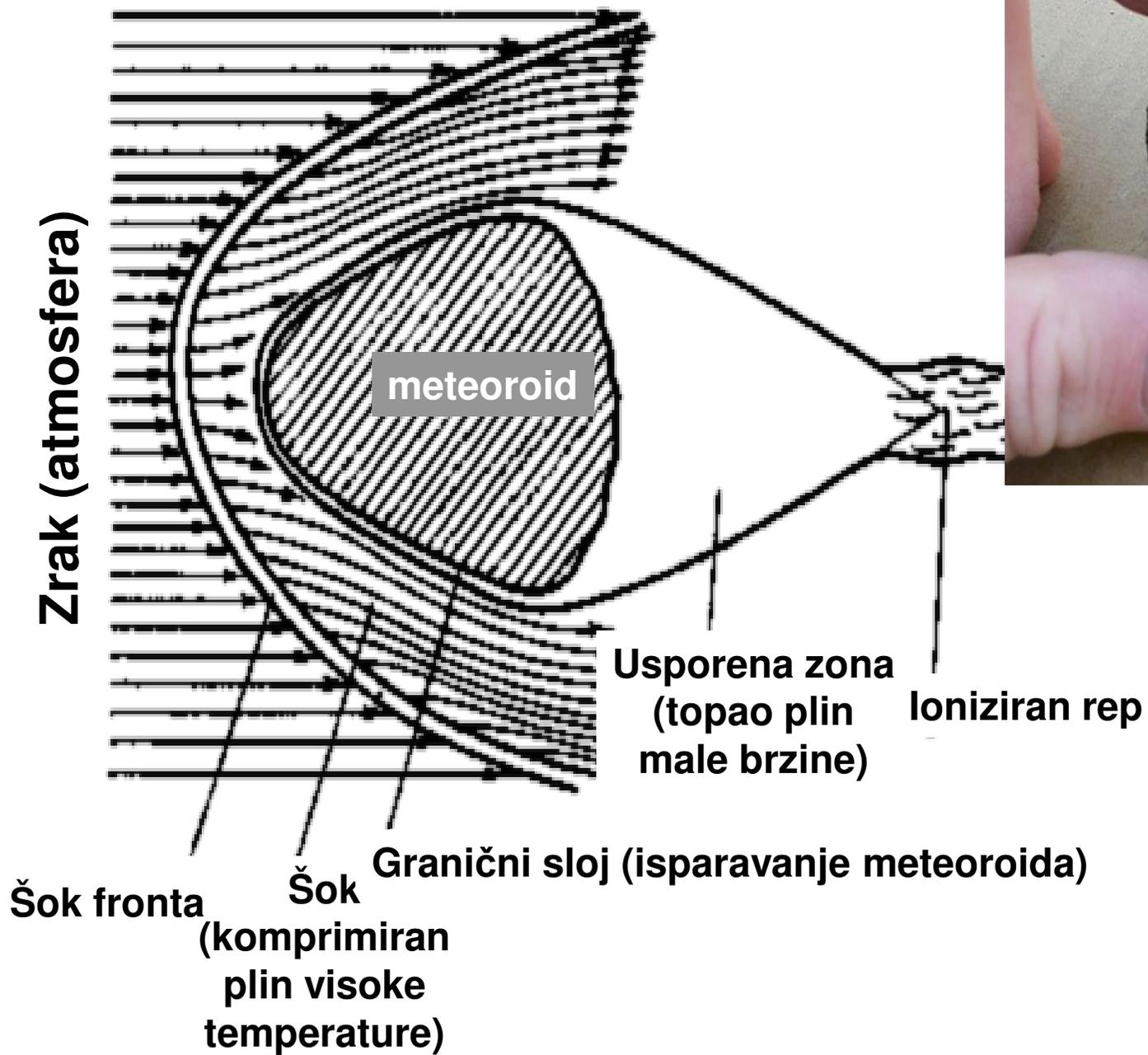
(vrlo sjajan meteor)



meteorit

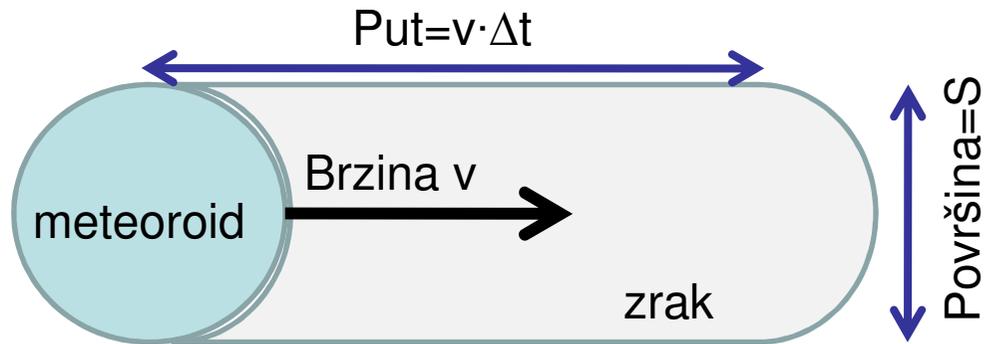
(objekt koji je pao na tlo)





- ulazak u atmosferu pod 20° u odnosu na horizont
- $\sim 17\text{m}$ promjer ?
- 7000-10000 tona ?
- eksplozija $\sim 500\,000$ tona TNT (30 Hiroshima)
- brzina 16.5 ± 3 km/s
- početak raspada na 40 ± 7 km
- finalni raspad na 23 ± 2 km





Masa zraka kojeg tijelo odmakne = $\Delta m_{zrak} = \rho_{zrak} \cdot v \Delta t \cdot S$

Brzina kojom se miče odmaknuti zrak = $v_{zrak} = \Gamma \cdot v$

Sila potrebna za odmicanje zraka = $F_{otpor} = -\frac{\Delta m_{zrak} \cdot v_{zrak}}{\Delta t} = -\Gamma S \rho_{zrak} v^2$

Definicija sile: $F = m \cdot \frac{\Delta v}{\Delta t}$

Promjena brzine tijela: $\frac{\Delta v}{\Delta t} = -\Gamma \frac{S}{m^{2/3}} \rho_{zrak} \frac{v^2}{m^{1/3}}$

$$\frac{\Delta v}{\Delta t} = -K \rho_{zrak} \frac{v^2}{m^{1/3}}$$

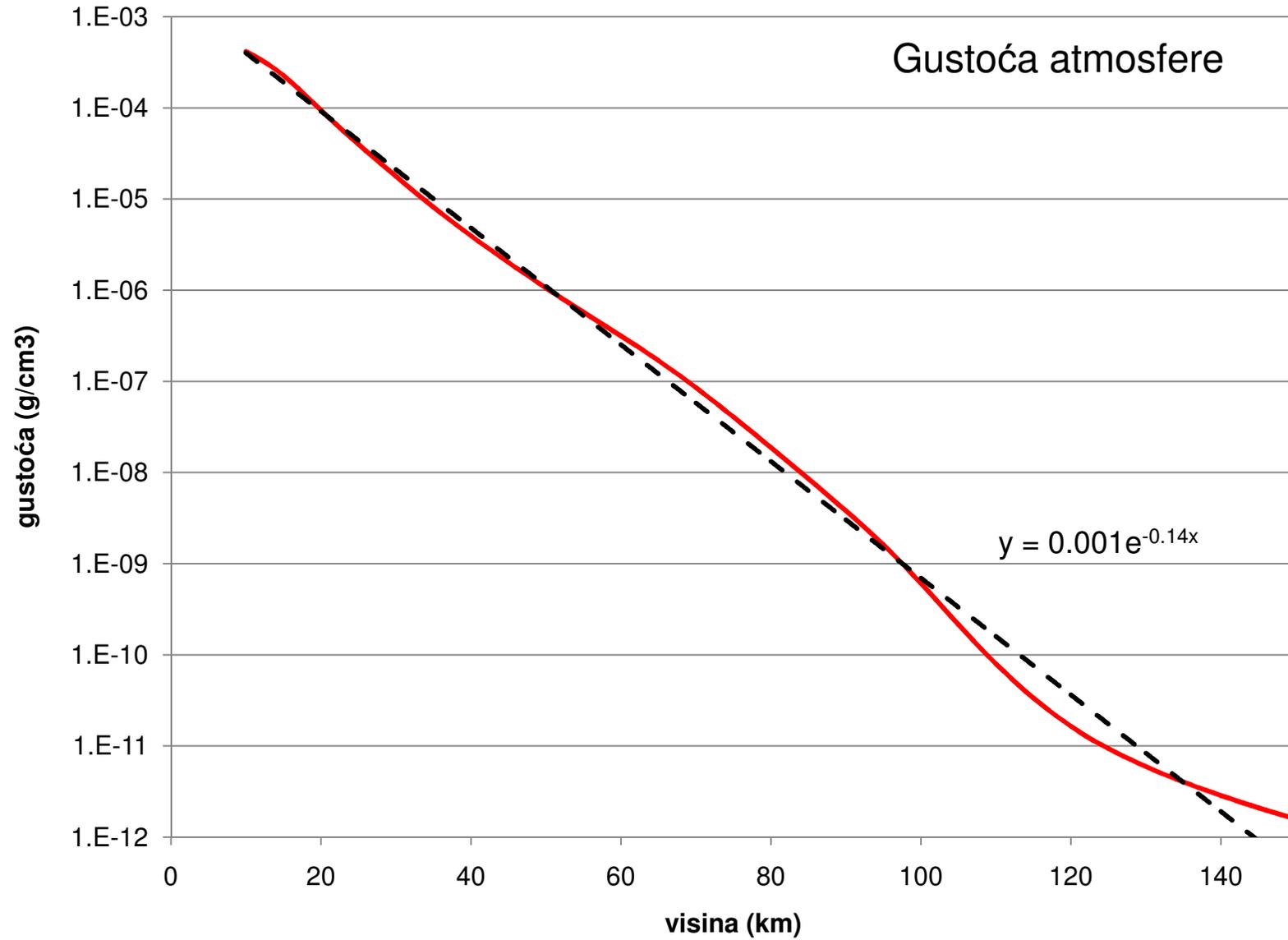
\approx konstanta ($S \sim R^2$, $m^{2/3} \sim R^2$)

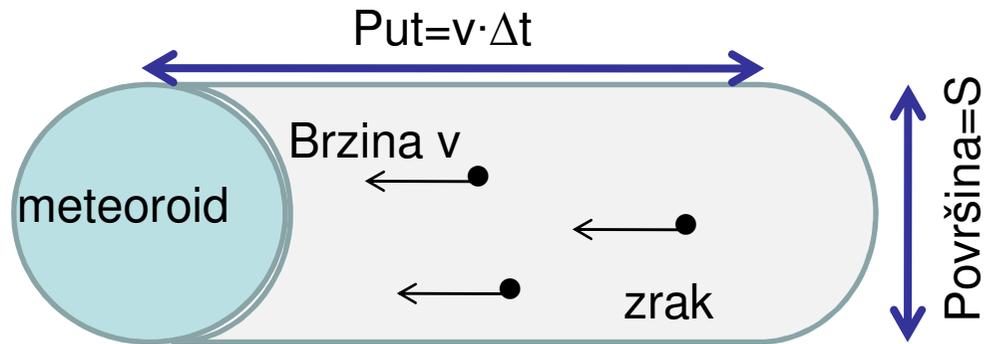
Kamena kocka:
$$K = \Gamma \frac{S}{m^{2/3}} \approx \Gamma \frac{R^2}{(\rho_m R^3)^{2/3}} = \Gamma \frac{1}{(\rho_m)^{2/3}}$$

$$\left. \begin{array}{l} \rho_m \approx 3 \text{ [g / cm}^3\text{]} \\ \Gamma \approx 1 \end{array} \right\} K \approx 0.48 \text{ [cm}^2 \text{ / g}^{2/3}\text{]}$$

$$K \approx 0.48 \text{ [cm}^2 \text{ / g}^{2/3}\text{]}$$

http://ccmc.gsfc.nasa.gov/modelweb/models/msis_vitmo.php





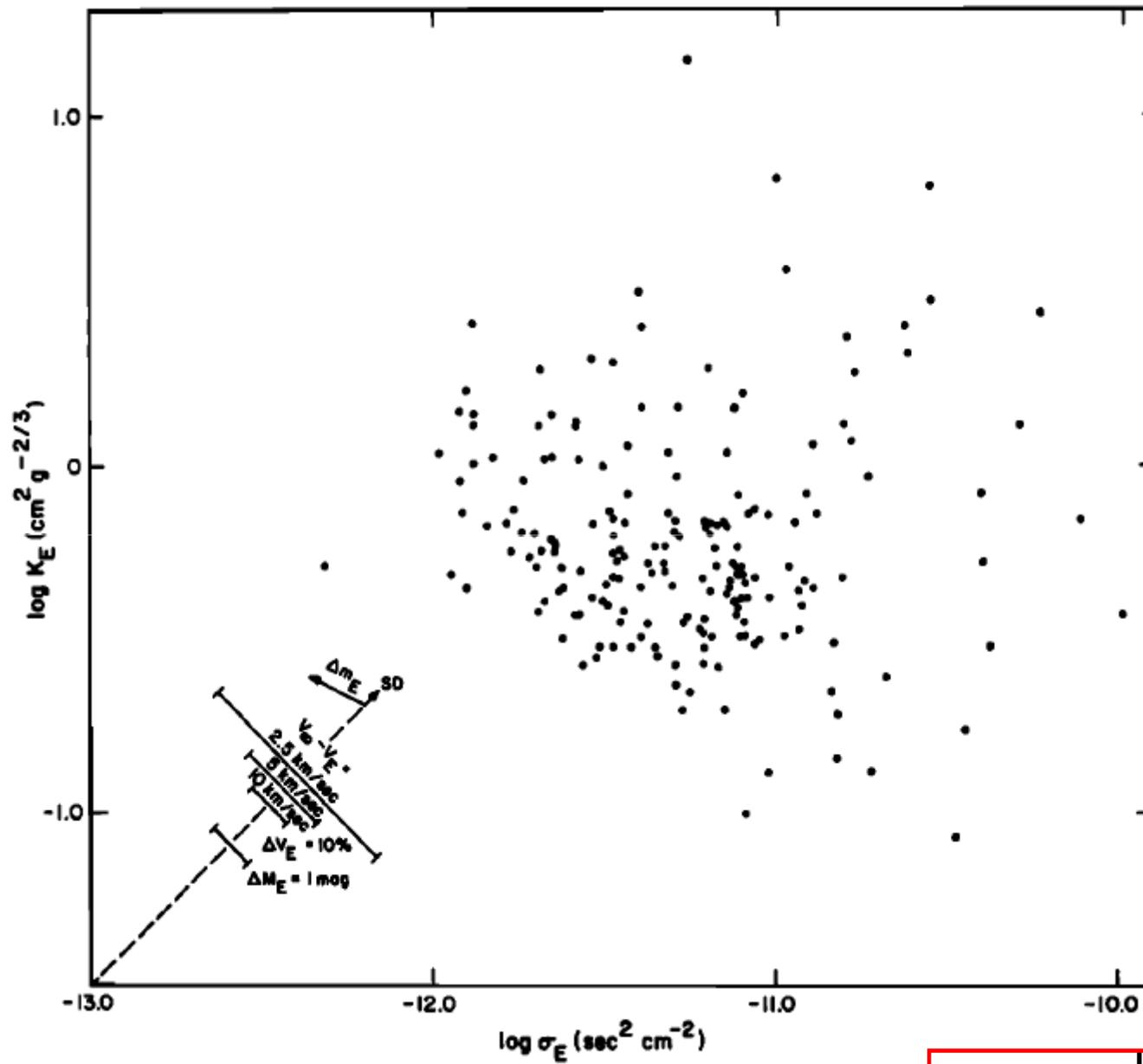
Kinetička energija zraka deponirana na tijelo udarima molekula zraka = $\Delta m_{\text{zrak}} \frac{v^2}{2} = \rho_{\text{zrak}} \cdot v \Delta t \cdot S \cdot \frac{v^2}{2}$

Dio kinetičke energije pretvoren u toplinu = $\Lambda \cdot \Delta m_{\text{zrak}} \frac{v^2}{2}$

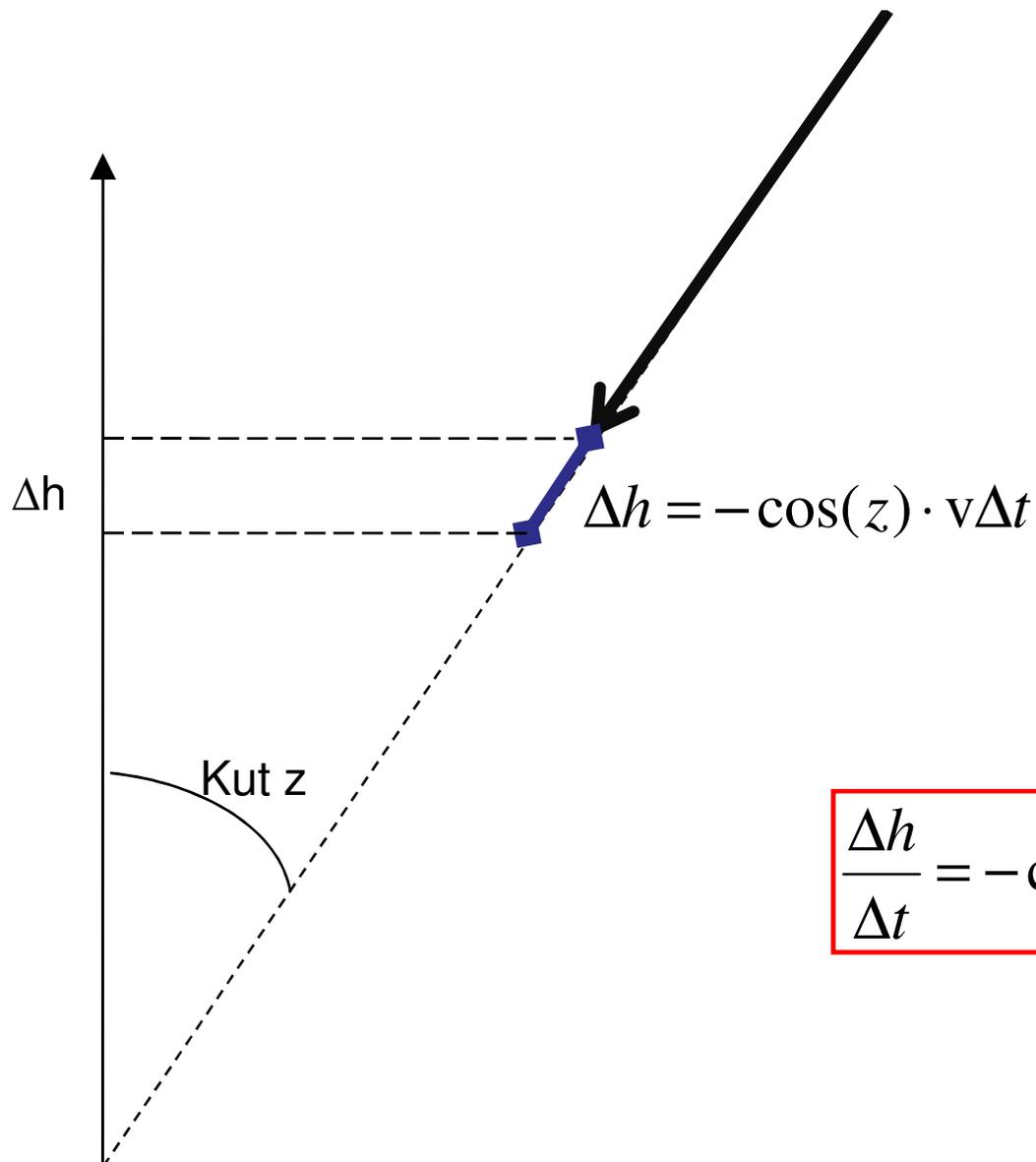
Energija izgubljena na isparavanje mase Δm je = $-\xi \cdot \Delta m$ ($\Delta m < 0$)

Očuvanje energije: $-\xi \cdot \Delta m = \frac{\Lambda}{2} \cdot \frac{S}{m^{2/3}} \cdot \rho_{\text{zrak}} \cdot m^{2/3} \cdot v^3 \cdot \Delta t$

$\frac{\Delta m}{\Delta t} = -\sigma K \rho_{\text{zrak}} m^{2/3} v^3$ \approx konstanta ($S \sim R^2$, $m^{2/3} \sim R^2$)

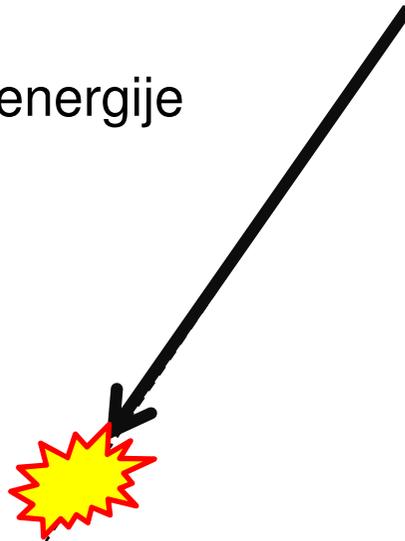


$$\sigma \approx 10^{-11} \left[s^2 / cm^2 \right]$$



$$\frac{\Delta h}{\Delta t} = -\cos(z) \cdot v$$

Dio izgubljene kinetičke energije
pretvara se u svjetlo



Gubitak kinetičke energije unutar Δt vremena = $-\Delta E_{kin}$

Sjaj I dobiven unutar Δt vremena = $I \cdot \Delta t = -\tau \cdot \Delta E_{kin}$

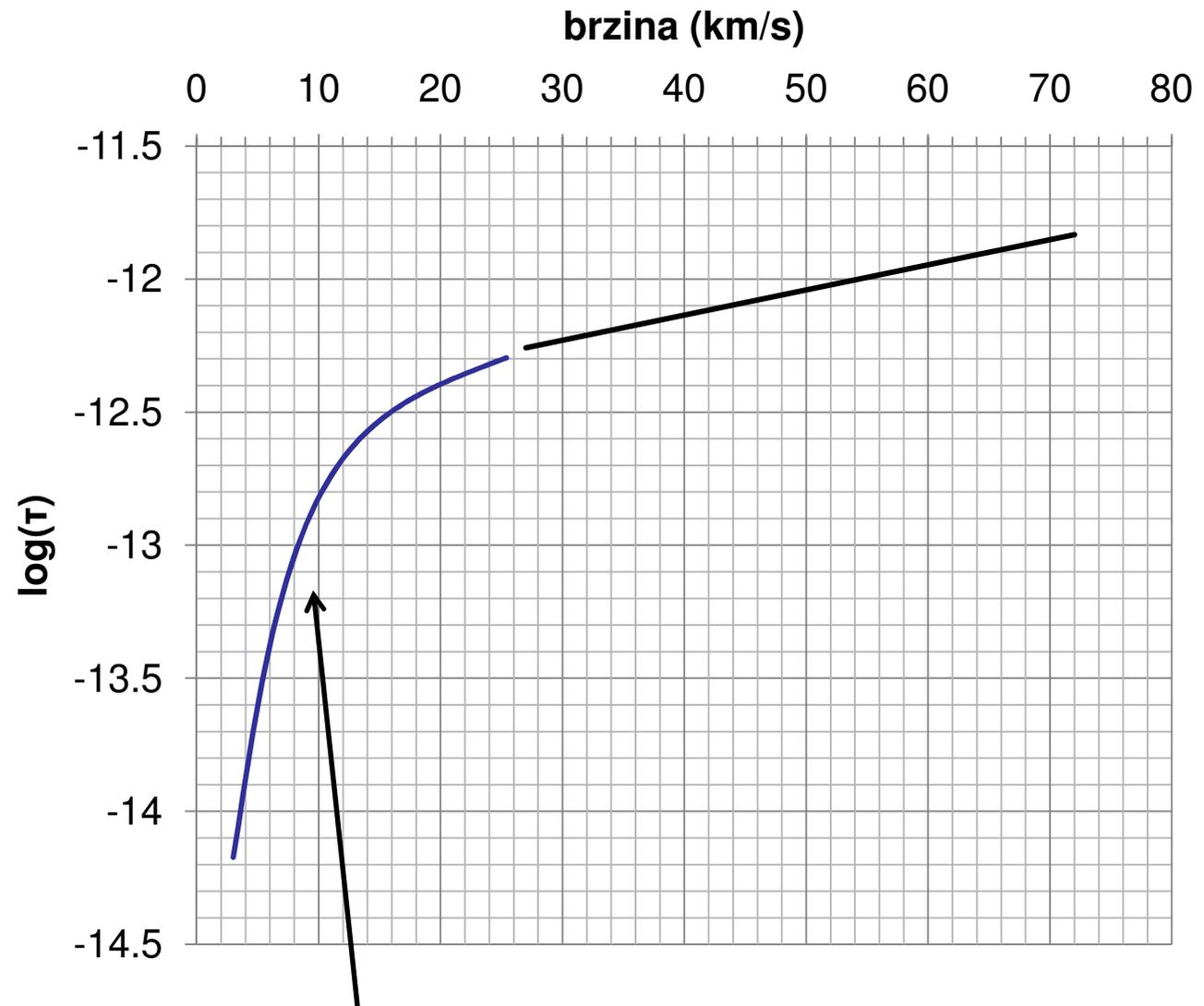
$$I = -\tau \cdot \frac{\Delta E_{kin}}{\Delta t} = -\tau \cdot \frac{\Delta(mv^2 / 2)}{\Delta t}$$

Okno reagira
logaritamski:

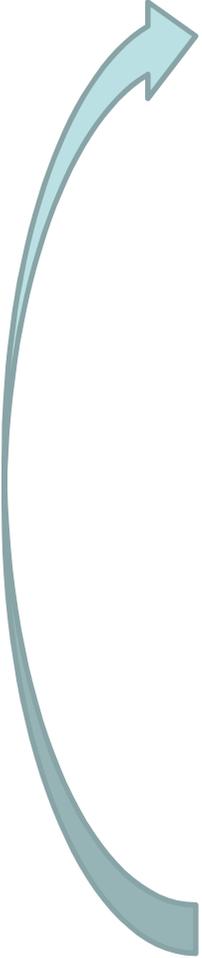
$$M = -2.5 \log I = -2.5 \log \left(-\tau \cdot \frac{\Delta(mv^2 / 2)}{\Delta t} \right)$$

Sunce $M=-26.7$ Puni Mjesec $M=-12.7$ Sirius $M=-1.47$

Općenito: τ ovisan o brzini, masi, materijalu



$$\log(\tau) = -12.834 - 10.307 \cdot \log(v) + 22.522 \cdot \log(v)^2 - 16.125 \cdot \log(v)^3 + 3.922 \cdot \log(v)^4$$


$$h \equiv h + \Delta h = h - \cos(z) \cdot v \cdot \Delta t$$


$$v \equiv v + \Delta v = v - K\rho_{zrak} \frac{v^2}{m^{1/3}} \Delta t$$


$$m \equiv m + \Delta m = m - \sigma K\rho_{zrak} m^{2/3} v^3 \Delta t$$


$$M = -2.5 \log I = -2.5 \log \left(-\tau \cdot \frac{\Delta(mv^2 / 2)}{\Delta t} \right)$$

VIDI RAČUN U POPRATNOJ EXCEL DATOTECI:
model_meteora.xlsx

Udari u tlo Zemlje su rijetki

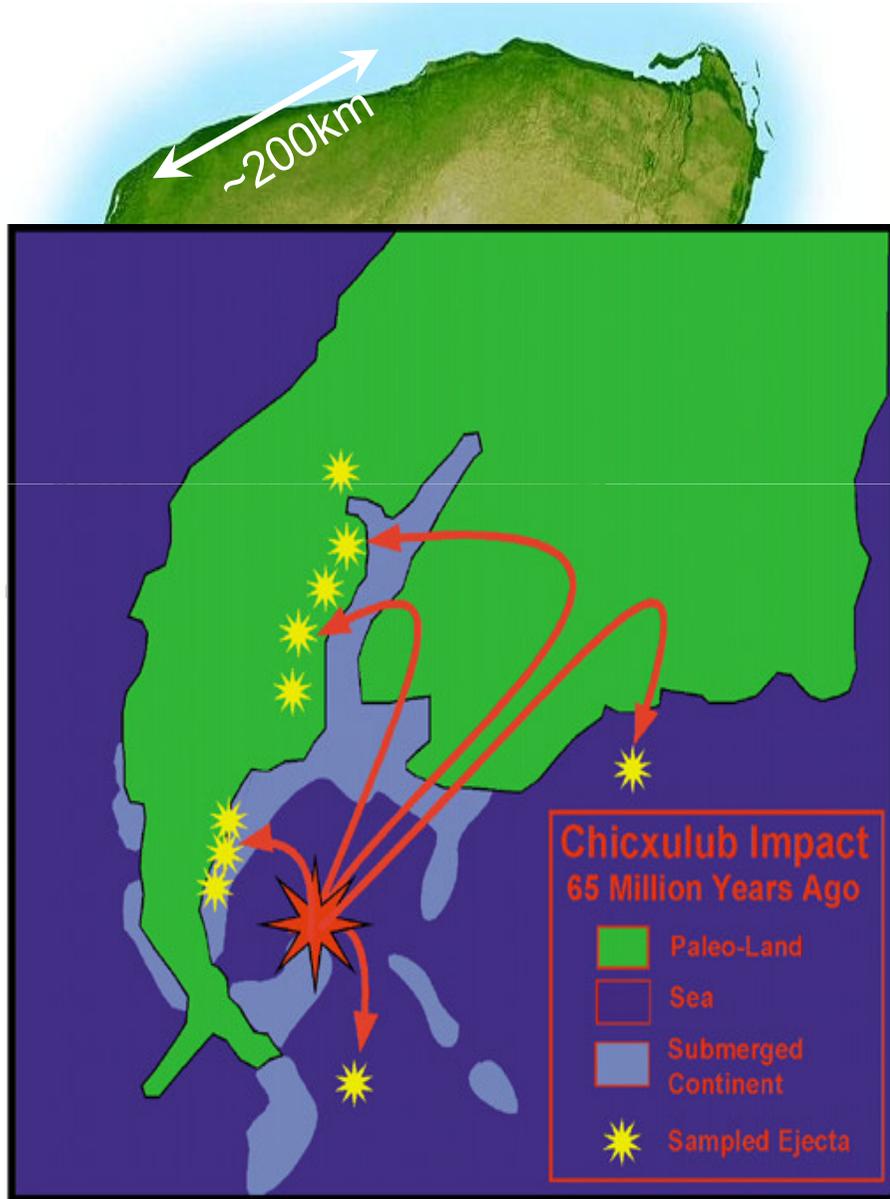


Tunguska eksplozija
devastacija površine $\sim 2000\text{km}^2$
1908 godina
(stjenovit impaktor od $\sim 50\text{m}$)

krater u Arizoni
promjer 1.2 km
starost 49,000 godina
(metalni impaktor od $\sim 50\text{m}$)



Chicxulub krater u Meksiku
promjer oko 200km (10km impaktor)
starost = 65mil godina (Dino killer)



Manicouagan Crater u Kanadi
promjer oko 70km
starost = 214mil godina
(5km impaktor)

