Reflecting on Explosions from nuclear to astrophysics

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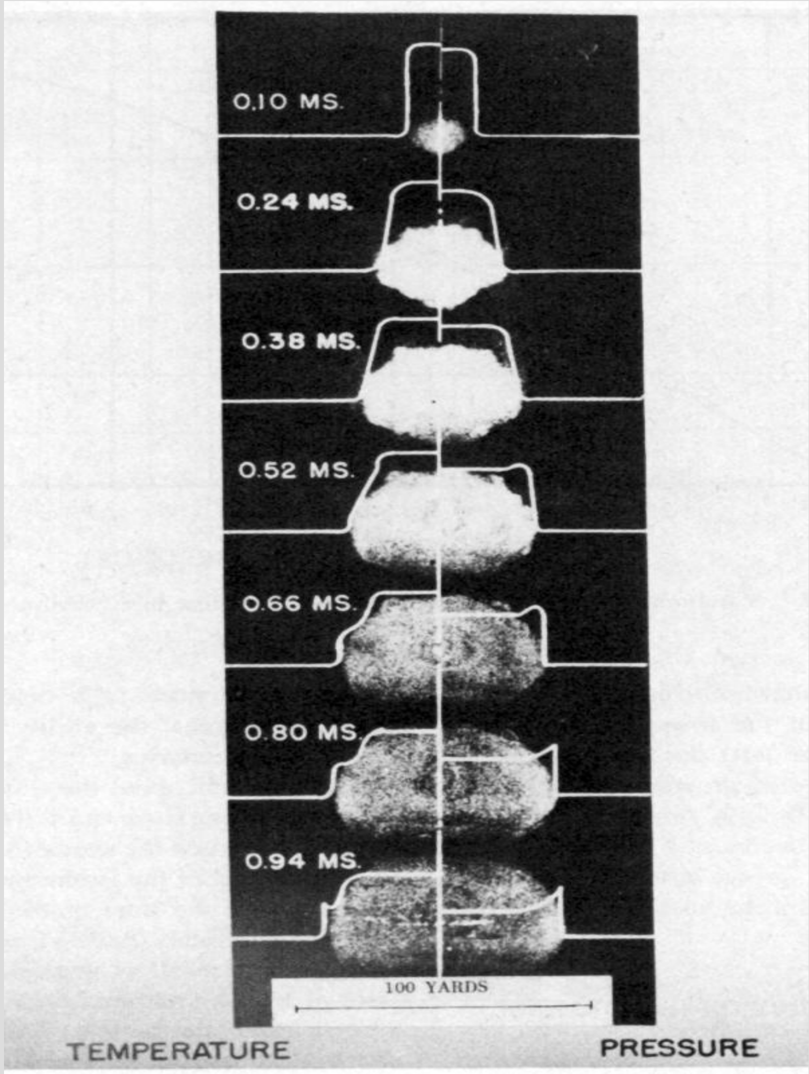
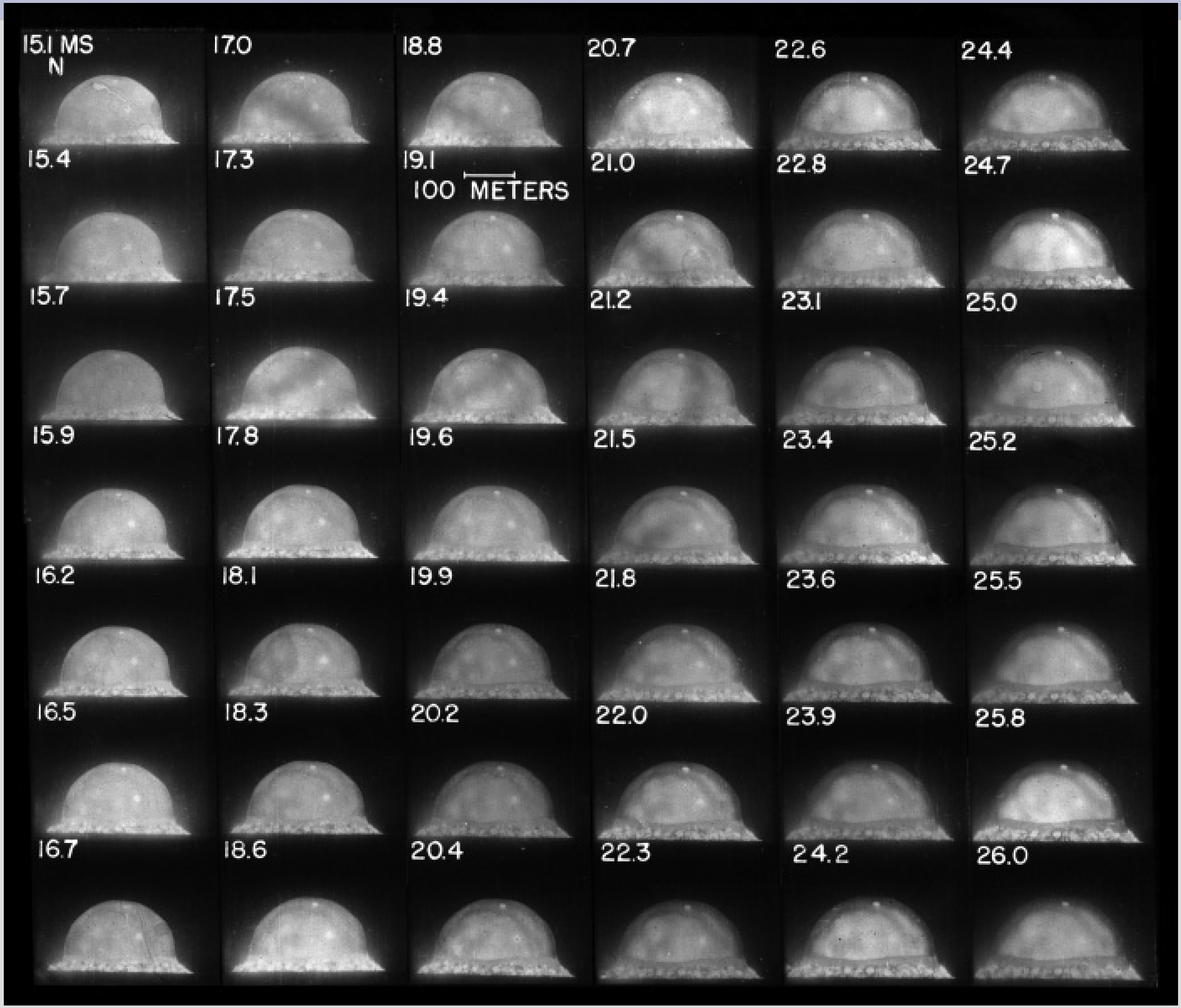
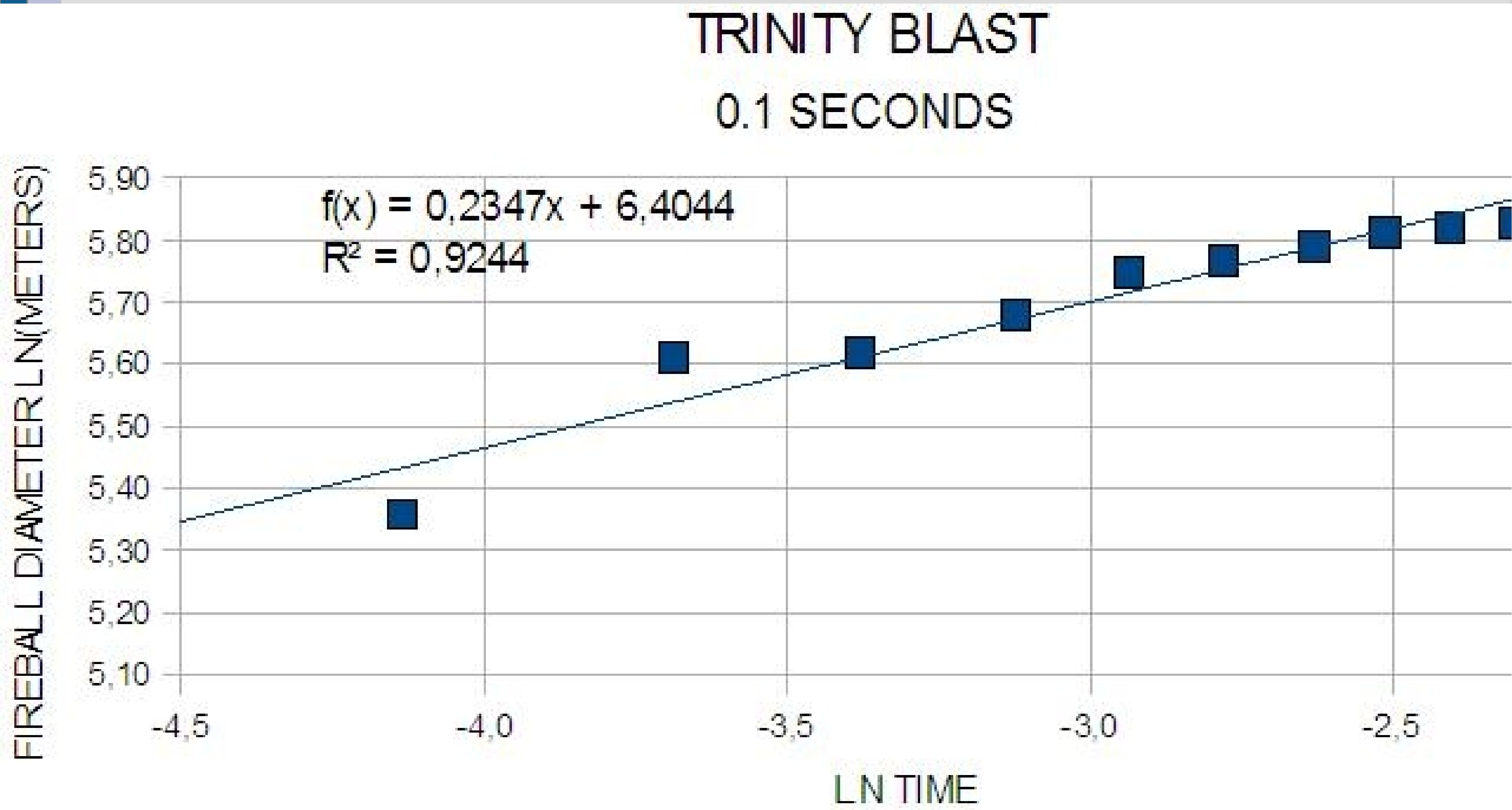
Nuclear: 0.1-0.94 ms



Nuclear: 15-26 ms

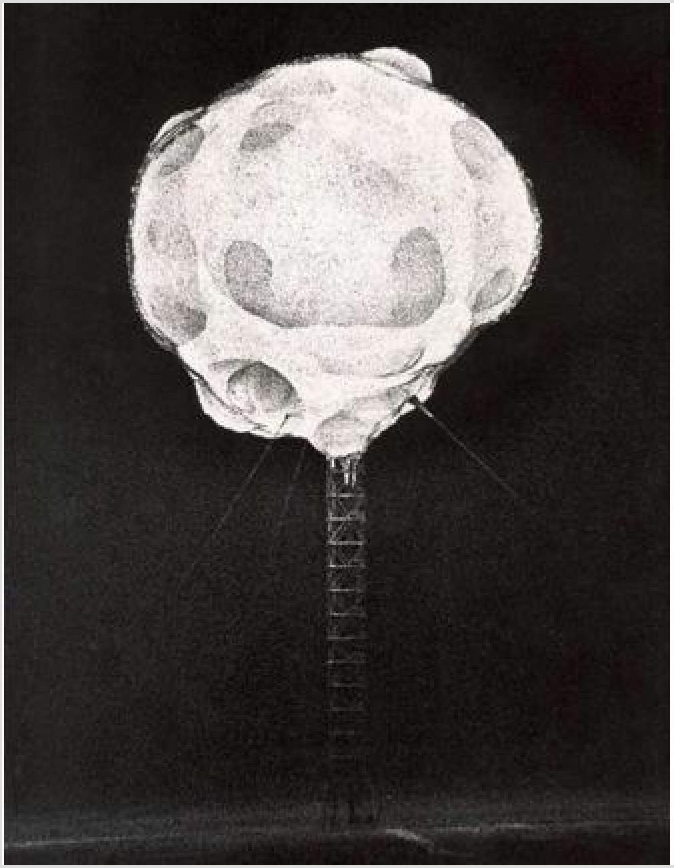


Nuclear Blast fireball-shock wave $d(t)=A*t^n$; $n=0.235\pm0.01$



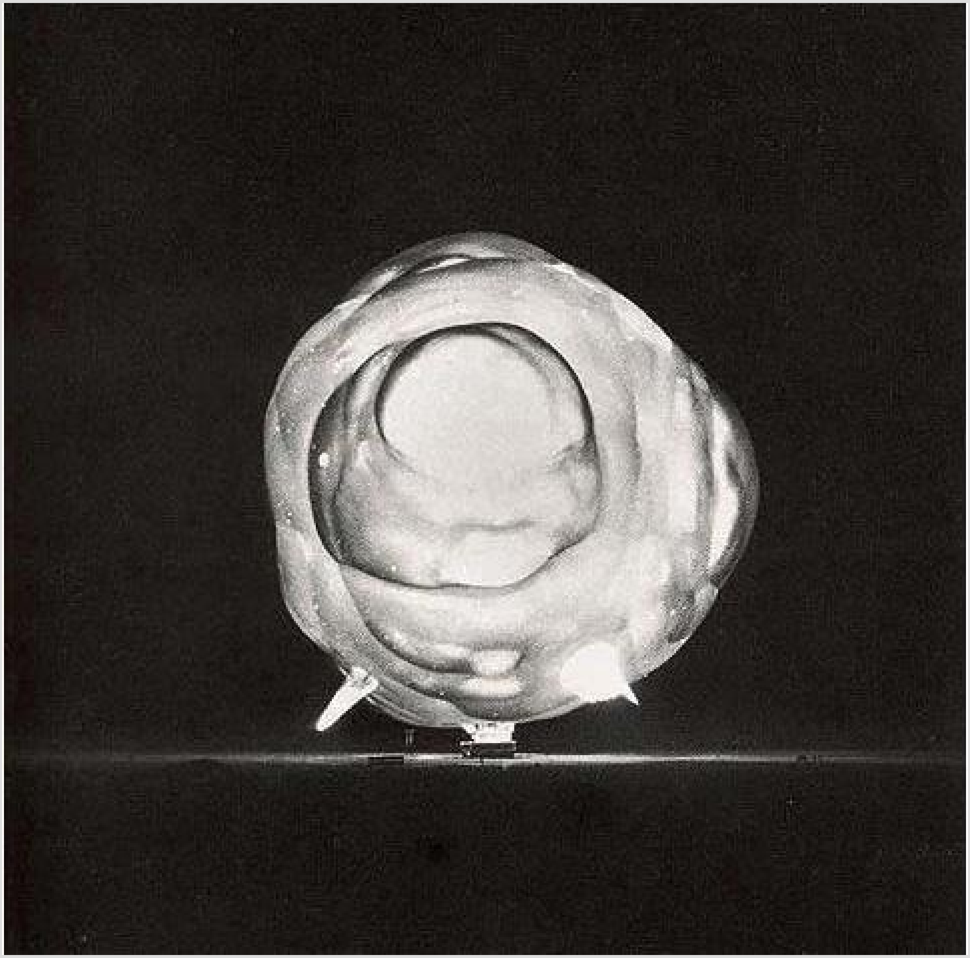
Nuclear Blast d(t)=600*t^1/5

- Steps: 10^-8 s
- 1) 15.2m



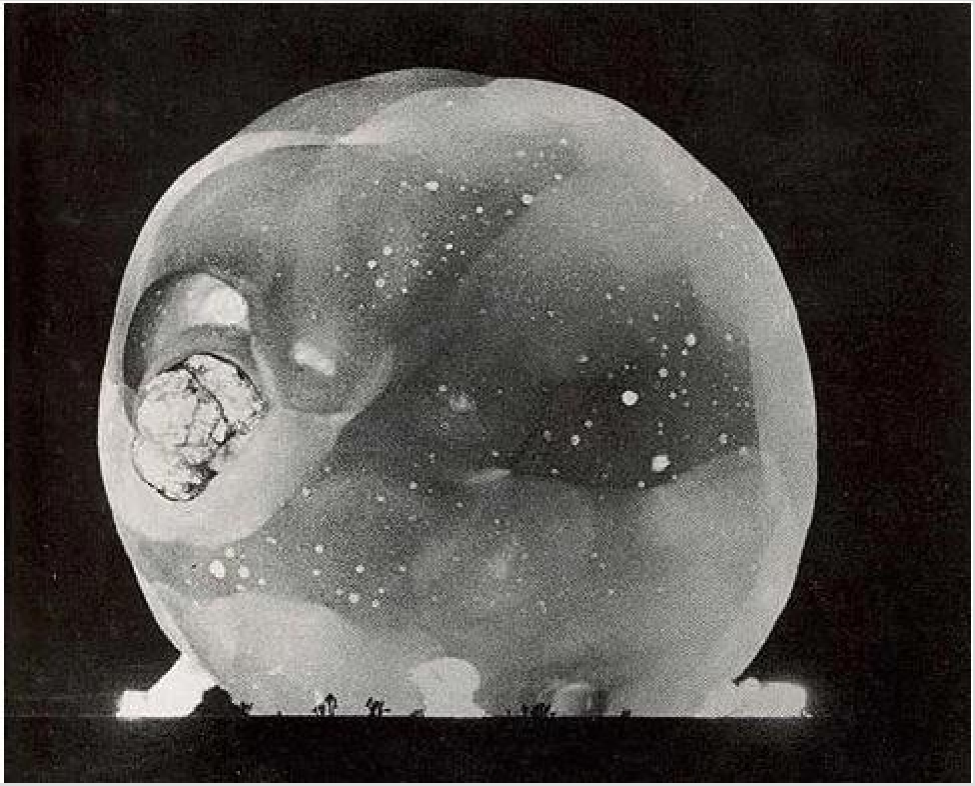
Nuclear Blast d(t)=600*t^1/5

- Steps: 10^-8 s
- 2) 17.5m



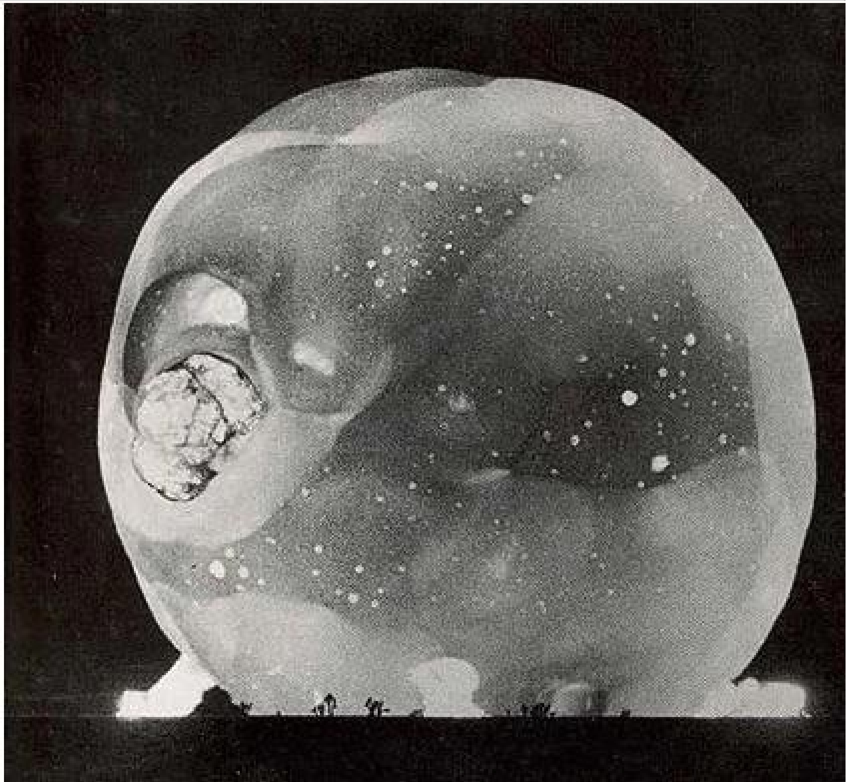
Nuclear Blast d(t)=600*t^1/5

- Steps: 10^-8 s
- 3) 18.9m

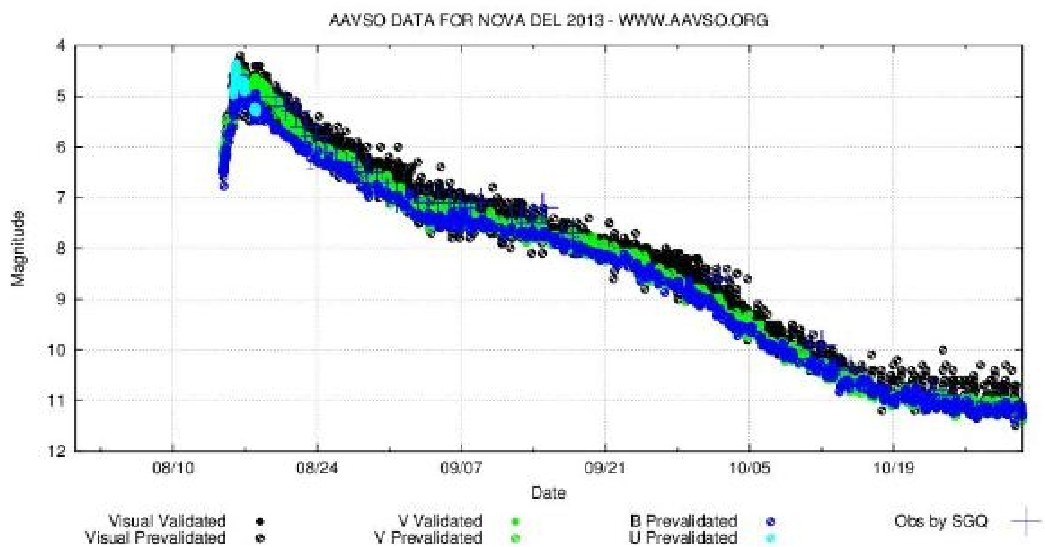


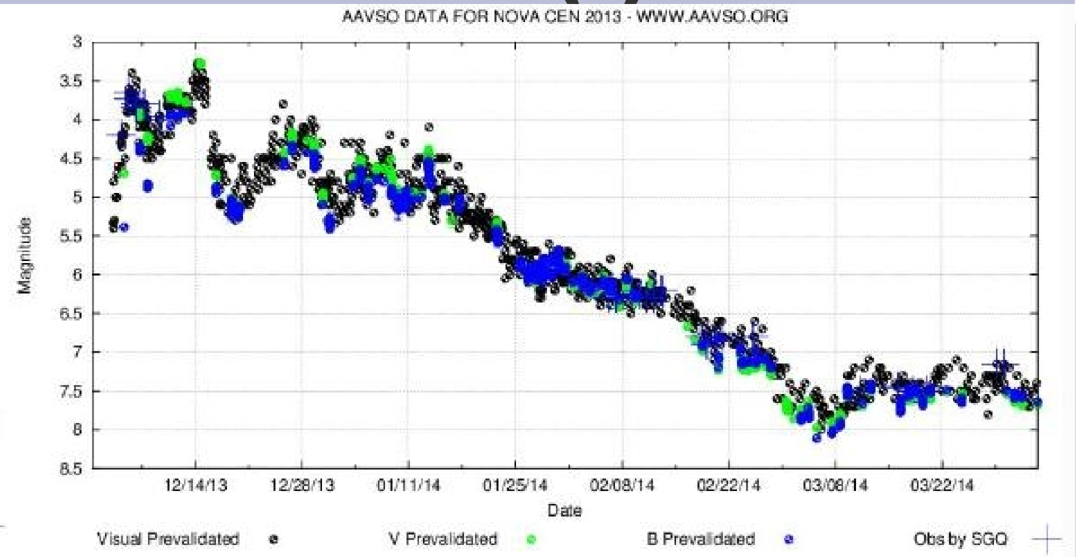
Nuclear Blast Int(t)≈4πr²(t) d(t)=600*t^1/5; Int(t)≈t^2/5

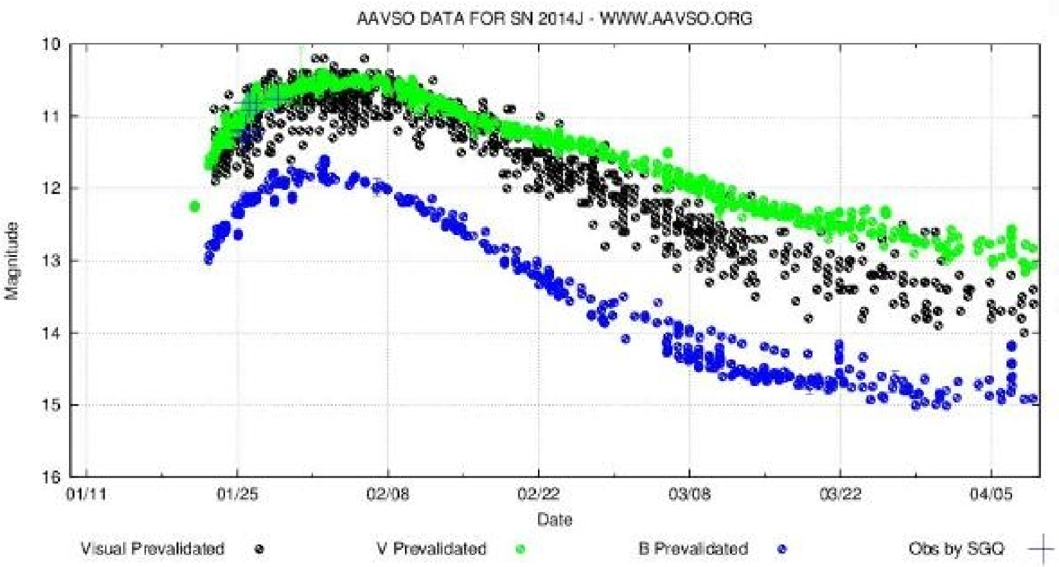
- The Fireball luminosity is proportional to the area of the fireball
- L ≈t^0.4
- Grows up to a limit
- After there is a decay

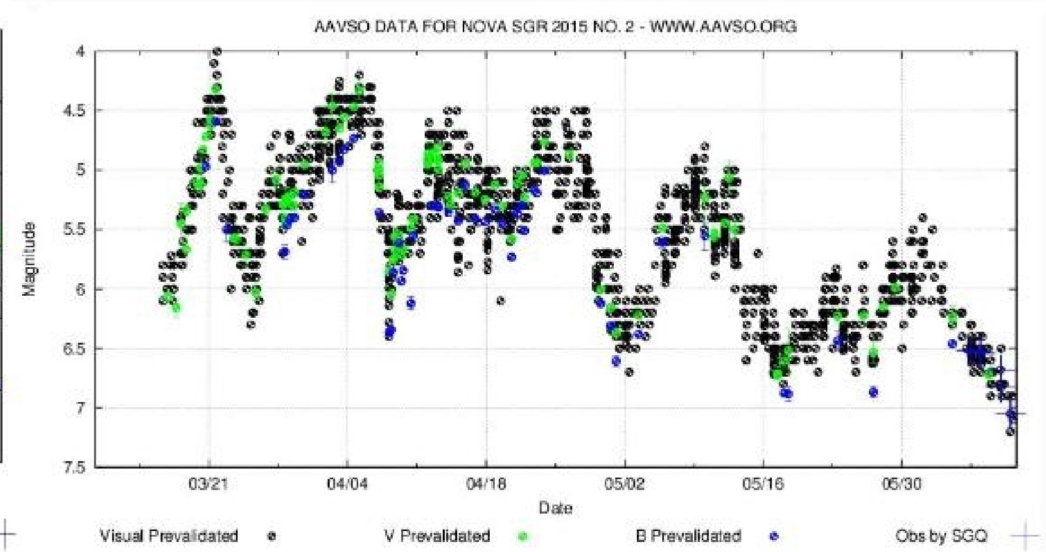


Novae and SN: days to months power-law light curves ln(l) vs t









Novae: absolute magnitude calibration (≠fireball dimension)

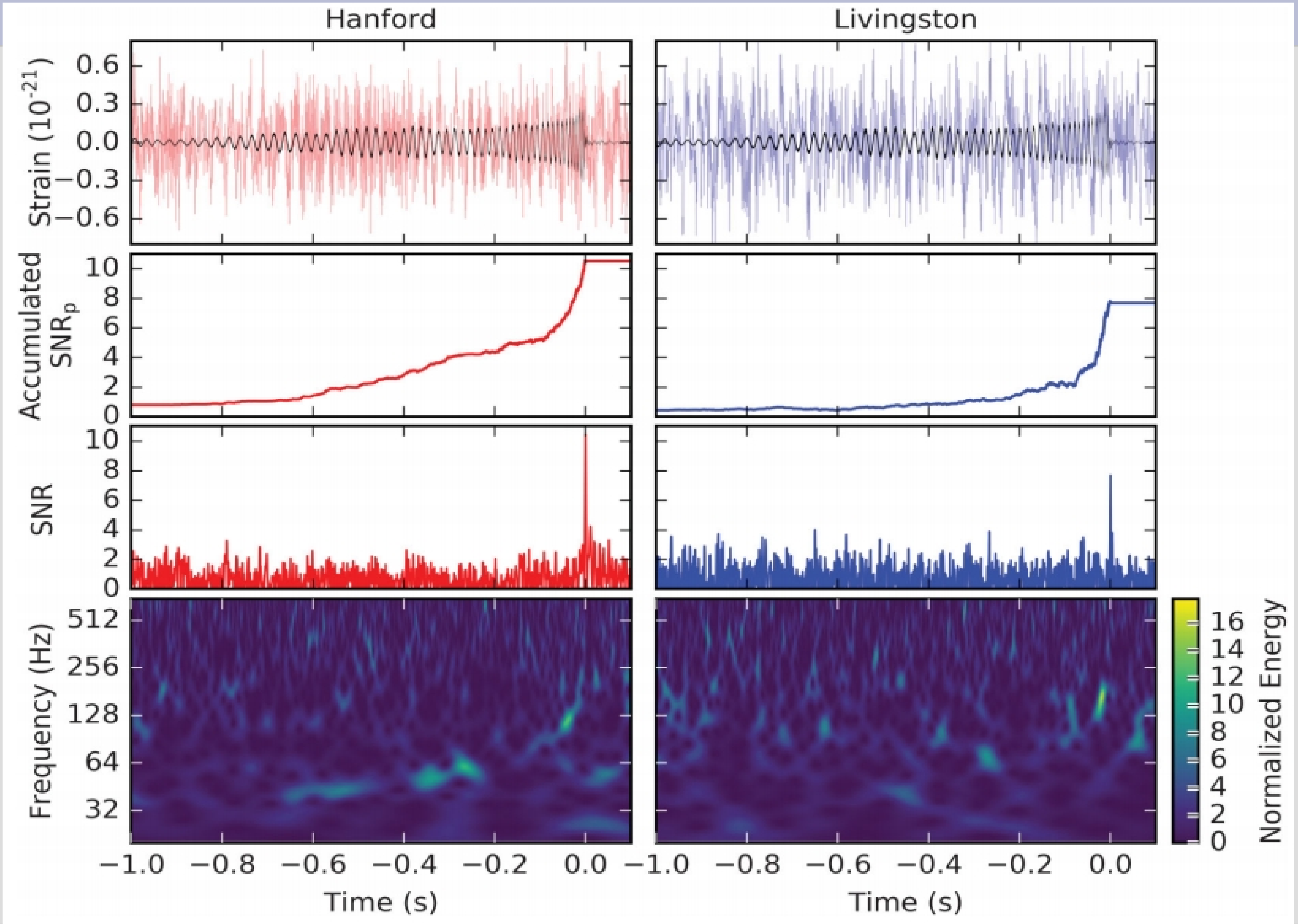
The rapidity of the decay is proportional to the absolute Mag:
the faster the brighter

$\Delta M/\Delta t = 0.02$ mag/day   Mabs=-6.5

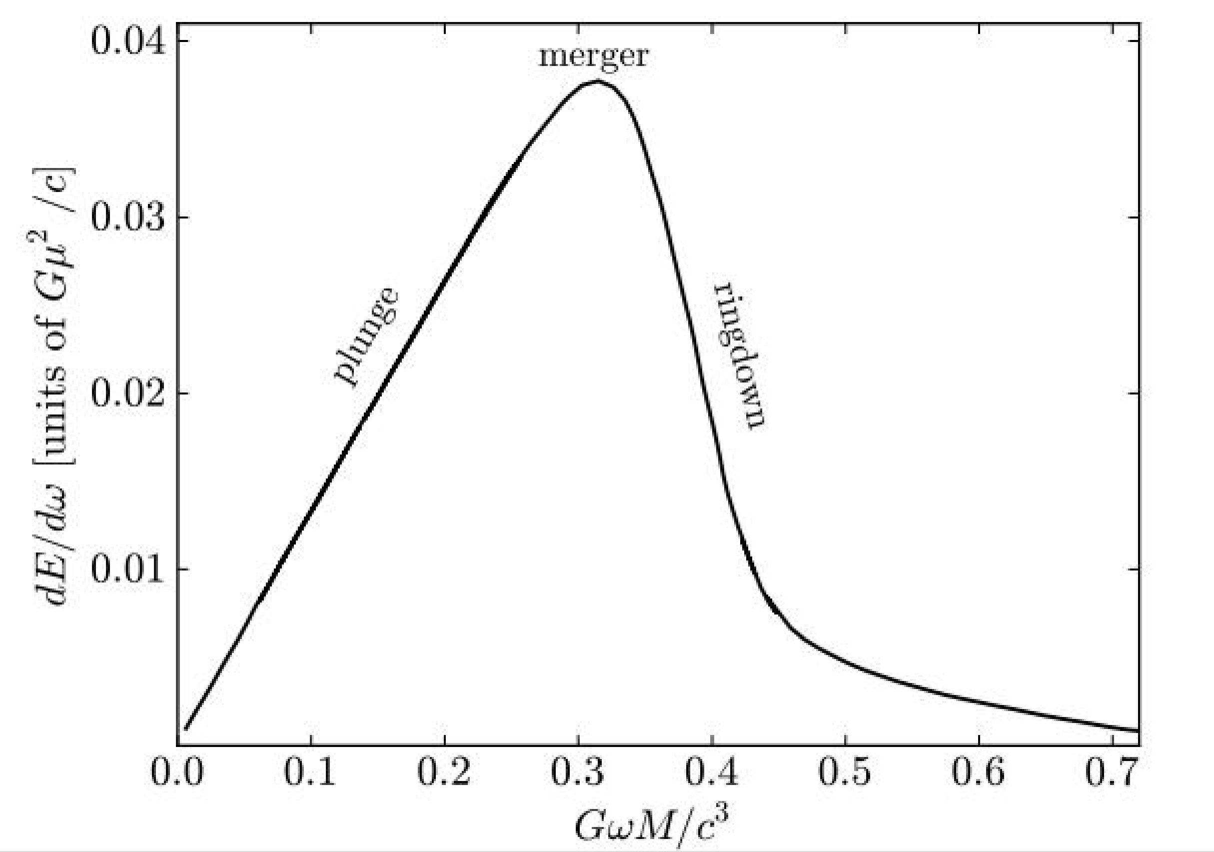
$\Delta M/\Delta t = 0.2$ mag/day   Mabs=-9

From L. Rosino P. Tempesti 1983

Gravitational waves: 0.1 s scale



GW: energy release (theory) R³: arxiv 2016-05-16 dE/dω vs E similar to Novae light curves



Explosions Curves: rising phase and decay

- Rising: t^(0.4) in atmosphere
- More rapid in empty space:
- Novae -10 magnitudes=x10^4 intensity in 2 days
- Supernovae -15↔20 mag=x10^6↔8 in 2d
- Decay: always exponential (same as power law)

Decay law

- The differential equation for an exponential decay is
- $-\Delta Q/\Delta t$ proportional to Q

the faster the brighter

- So that
- $Q=Q_o exp(-t/\tau)$
- with $\tau=Q/T$ the time required to reduce by 1/3 (1/e) the initial Q_o

Universal law for decay: examples

- Novae and Supernovae light curves
- Langevin function (magnetism, hystheresis)
- Equilibrium thermodynamics (thermometric equation)
- Fourier currents and Lenz law
- Condensator discharge....

Quiz on Industrial Revolution 1/2

The Industrial Revolution started

- 2 years ago
- 20 years ago
- 200 years ago

Answer :200 years ago

Quiz on Industrial Revolution 2/2

In 200 years mankind consumed some amount of resources (hydrocarbures)

How much time needed to gather all these resouces?

- 200 million years
- 2000 years
- 200 years

Answer: 200 million years

Results of the Quiz

The Ratio is 200 million years / 200 years

= 1 million:

it is an EXPLOSION according to Gamow's definition

Geroge Gamow (1950) on Nuclear Explosions (AE, 152)

The expansion of the hot gas is slower than the chemical reaction then the destructive shock wave produces an EXPLOSION

The nuclear reaction is not as fast, but the amount of energy per unit mass is 2*10^7 times the chemical one

The expansion is faster than the energy release, which continues during the expansion, while for chemicals does not (instant release).

Conclusions

Similarities between nuclear explosions on Earth and Novae explosions are obvious

Novae are binary driven events

The universality of exponential decay is shown

In particular for Supernovae, but also in GW from inspiralling Black Holes

Numerical study on the Trinity test 16/7/1945

to recover the behavior as $t^{(1/5)}$

Chemical and nuclear explosions are reviewed according to George Gamov