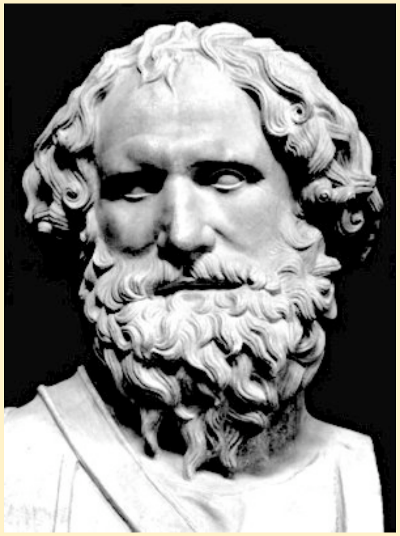
# Archimedes, Higgs, and Falling Honey

J. D. Jackson

CQS, December 14, 2009



Chris Quigg, Theoretical Physicist Extraordinaire

Un Boulevardier de Paris
et
Un Pèlerin De Santiago de Compostela

TWO REGGEON EXCHANGE CONTRIBUTIONS TO

HADRON SCATTERING AMPLITUDES AT

HIGH ENERGY

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September 14, 1970

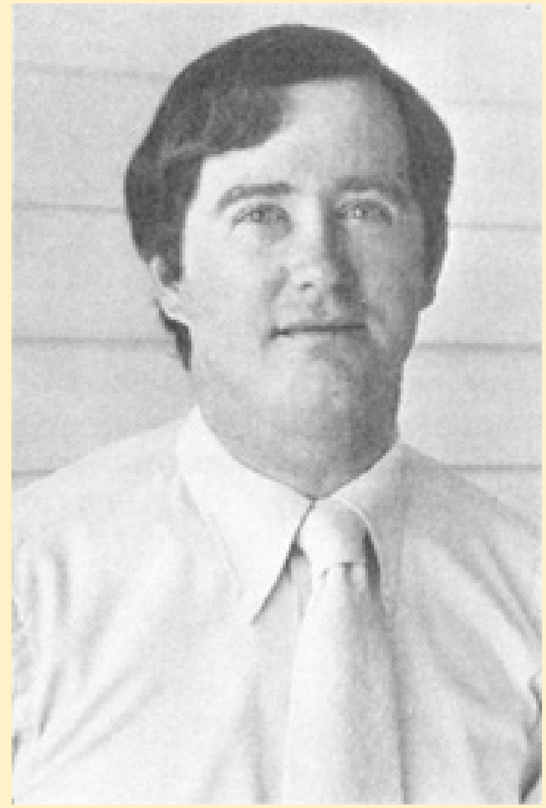
ABSTRACT

Regge cuts are discussed from a phenomenological point of view. Some attempts to derive amplitudes with Regge cuts are reviewed, including those of Amati, Stanghellini, and Fubini, and of Gribov. A phenomenological amplitude for the Regge cut from two Reggeon exchange is written down in a form that manifestly satisfies $s$-$u$ crossing. The amplitude is formulated in terms of s-channel helicity partial-wave amplitudes, so the Reggeization of s-channel helicity amplitudes is discussed as a technical simplification. Implications of Regge cuts for various duality-breaking schemes (and vice versa) are summarized. Brief remarks are made on two Reggeon cuts and exotic exchange. These include model calculations of the $(P' + \rho) \otimes (P' + \rho)$ cut in $\pi\pi$ scattering, and of the single-meson-exchange "forbidden" reaction $K^- p \to K^+ \Xi^-$.

# Undated Rap Sheet

## CHRIS QUIGG APPOINTED THEORY DEPARTMENT HEAD

Chris Quigg was appointed head of the Fermilab Theoretical Physics Department last week.



Blah, Blah, Blah

Quigg and his wife, Elizabeth, a member of the Computing Department, live in Wheaton. They have 2 children, David - four and Katherine- one.

Actually July 1977

# Archimedes and Higgs

Floating prisms and broken symmetry

Canadian conifer log booms

Brazilian log “boom” (wood is too heavy to be floated and towed economically; some don’t even float)

From the Works of Archimedes, by T. L. Heath, UCP, 1897

### Proposition 2.

*The surface of any fluid at rest is the surface of a sphere whose centre is the same as that of the earth.*

### Proposition 3.

*Of solids those which, size for size, are of equal weight with a fluid will, if let down into the fluid, be immersed so that they do not project above the surface but do not sink lower.*

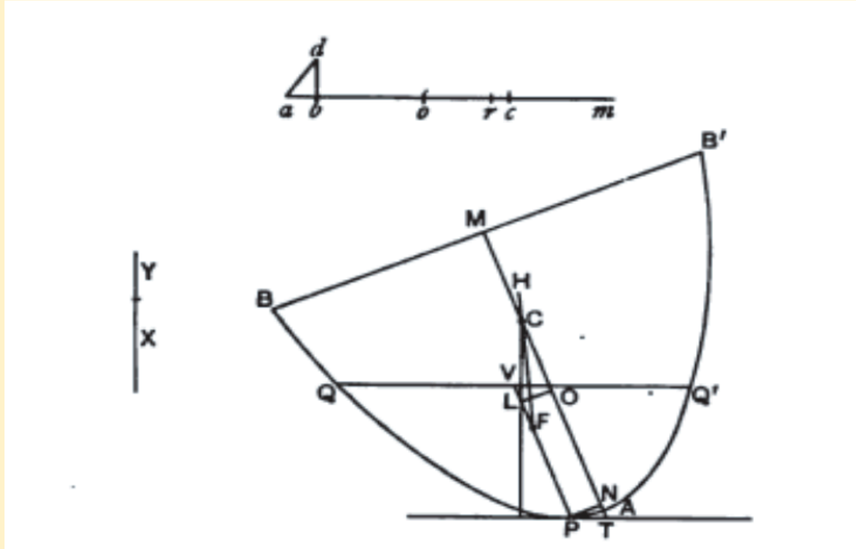
### Proposition 4.

*A solid lighter than a fluid will, if immersed in it, not be completely submerged, but part of it will project above the surface.*

### Proposition 5.

*Any solid lighter than a fluid will, if placed in the fluid, be so far immersed that the weight of the solid will be equal to the weight of the fluid displaced.*

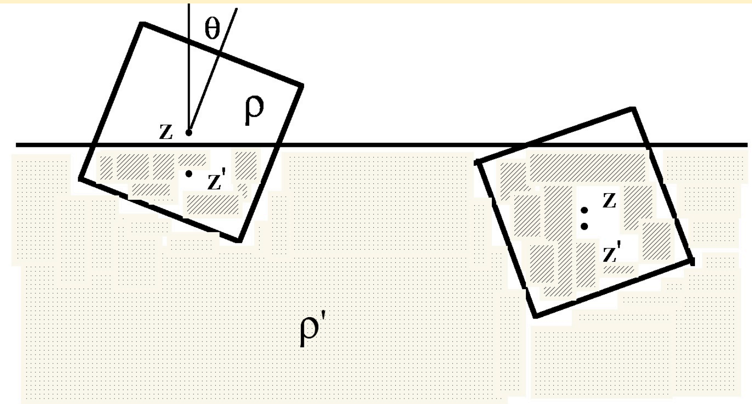
# Archimedes on a Floating Paraboloid of Revolution




### Proposition 8.

*Given a solid in the form of a right segment of a paraboloid of revolution whose axis AM is greater than* $\frac{3}{4}p$, *but such that* $AM : \frac{1}{2}p < 15 : 4$, *and whose specific gravity bears to that of a fluid a ratio less than* $(AM - \frac{3}{4}p)^2 : AM^2$, *then, if the solid be placed in the fluid so that its base does not touch the fluid and its axis is inclined at an angle to the vertical, the solid will not return to the position in which its axis is vertical and will not remain in any position except that in which its axis makes with the surface of the fluid a certain angle to be described.*

# Geometry of floating wooden prisms of square cross section




$$U(z, \theta) = g\rho V z - g\rho' V' z'$$

$$r = \rho/\rho'$$

Huygens (1650) - prism of square cross section

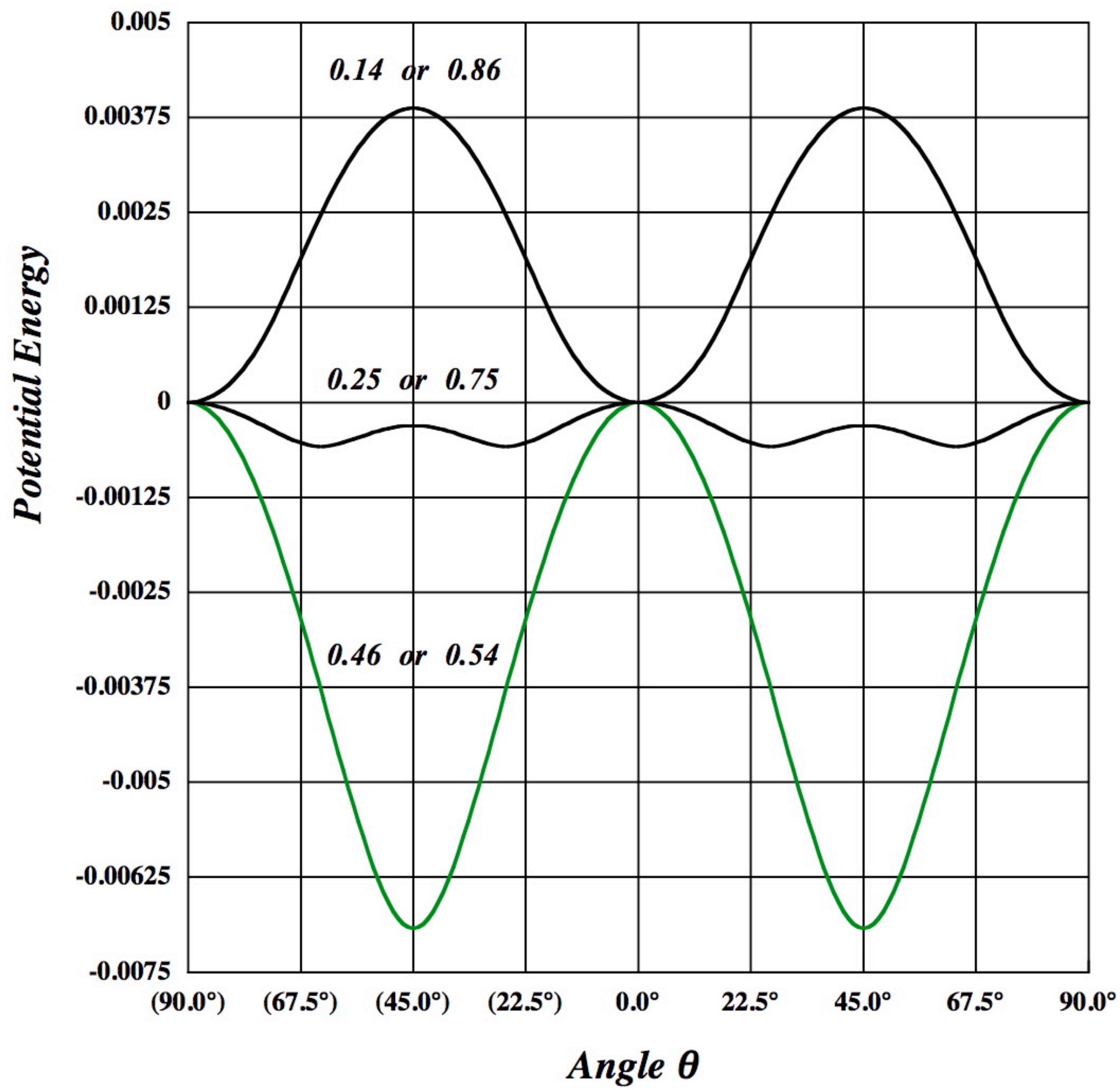
……

Pippard (present day) - Cambridge Examination

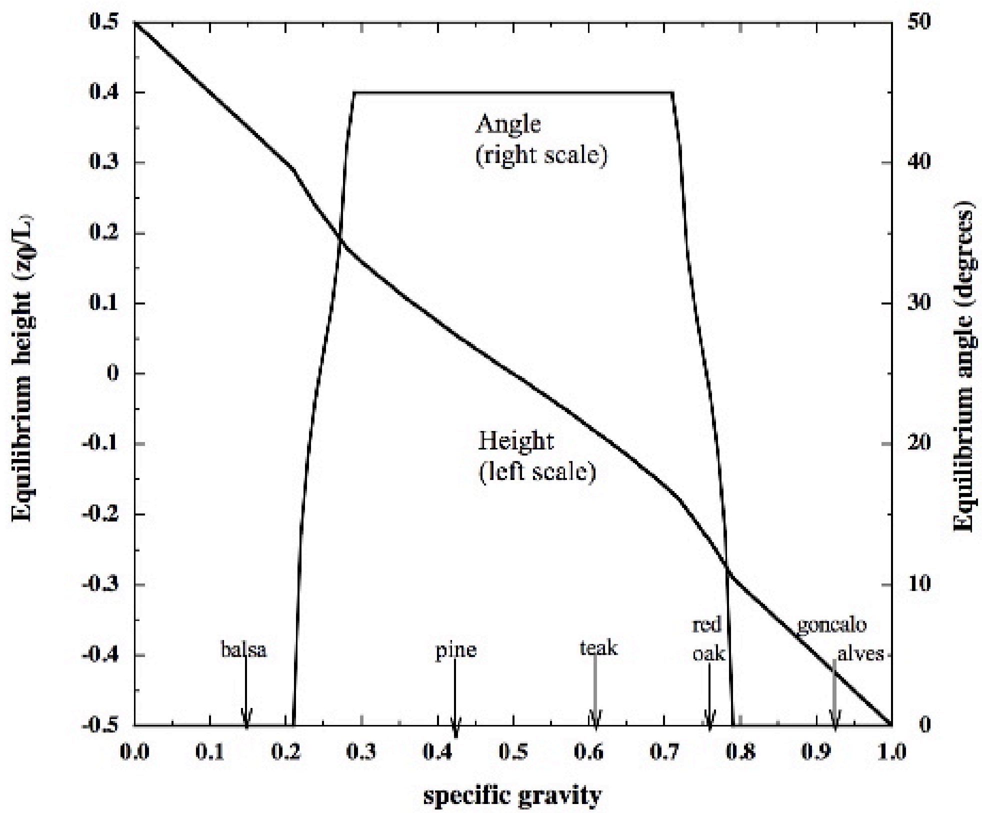
My Stimulus- Erdíos, Schliber & Herdon, AJP
**60**, 335, 345 (1992)

# Demonstration
# of
# Assorted Square Wooden Prisms

With questions and audience response



0.14 or 0.86
0.25 or 0.75
0.46 or 0.54
Potential Energy
0.005
0.00375
0.0025
0.00125
0
-0.00125
-0.0025
-0.00375
-0.005
-0.00625
-0.0075
(90.0°)
(67.5°)
(45.0°)
(22.5°)
0.0°
22.5°
45.0°
67.5°
90.0°
Angle θ




**Equilibrium height and angle of attitiude of floating square prisms of wood versus specific gravity**

# There is much more to consider about these prisms

## Small Oscillations about Equilibrium

Lagrangian:

$$L = \frac{1}{2}\rho_0 r\,\dot{z}^2 + \frac{1}{12}\rho_0 r\,\dot{\theta}^2 - U(z,\theta)$$

$$\frac{U(z,\theta)}{g\,\rho_0} \approx C + \frac{1}{2}u\,(z - z_0)^2 + v\,(z - z_0)(\theta - \theta_0) + \frac{1}{2}w\,(\theta - \theta_0)^2$$

Table of coefficients:

| Region number | Range of r | u | v | w |
|---|---|---|---|---|
| 1 | $0 < r < 0.211325$ | 1 | 0 | $[1 - 6r(1-r)]/12$ |
| 2 | $0.211.. < r < 1/4$ | $\sqrt{12\,r\,(1-r) - 1}$ | $\sqrt{2}(1/2-r)\sqrt{6r(1-r) - 1}$ | $\dfrac{6\,r\,(1-r) - 1}{3\sqrt{12\,r(1-r) - 1}}$ |
| 3 | $1/4 < r < 9/32$ | $2\sqrt{9/16 - r}$ | $(1/\sqrt{2})\sqrt{9/32 - r}$ | $\dfrac{4\,(9/32 - r)\,(3/4 - r)}{3\sqrt{9/16 - r}}$ |
| 4 | $9/32 < r < 1/2$ | $2\sqrt{r}$ | 0 | $\frac{4}{3}\,r\left(\sqrt{r} - \sqrt{9/32}\right)$ |

# But no time !

# On to Falling Honey !

1. Demonstrations
2. Dimensional Analysis

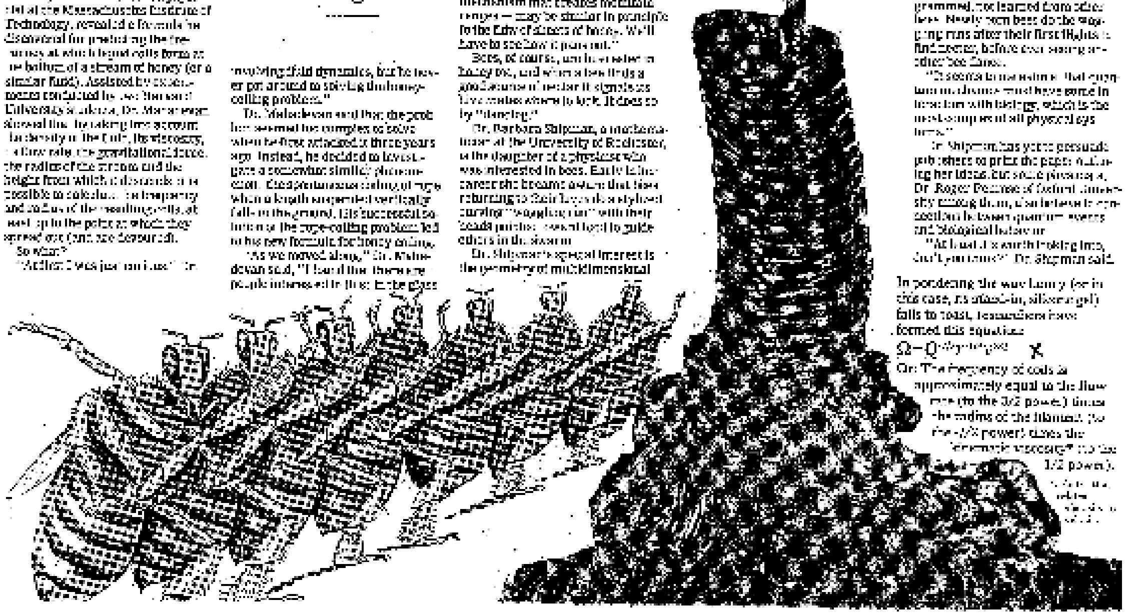
# Physicists Study the Honeybee For Clues to Complex Problems

By MALCOLM W. BROWNE

How doth the little busy bee improve each shining hour? By making honey, of course. But also by prompting scientists to think about the deep significance of gooey coils that pile up when honey is poured on toast, and how quantum mechanics might choreograph the dancing of bees.

Two papers that recently came to light (one in the March issue of Nature, and the other not yet accepted for publication) celebrated the humble honeybee, reminding readers that seemingly trivial problems can lead to weighty insights.

The choreography of coiling honey and dancing bees.



In pondering the way honey (or in this case, its stand-in, silicone gel) falls to toast, researchers have formed this equation:

Or: The frequency of coils is approximately equal to the flow rate (to the 3/2 power) times the radius of the filament (to the -1/2 power) times the "kinematic viscosity" (to the 1/2 power).

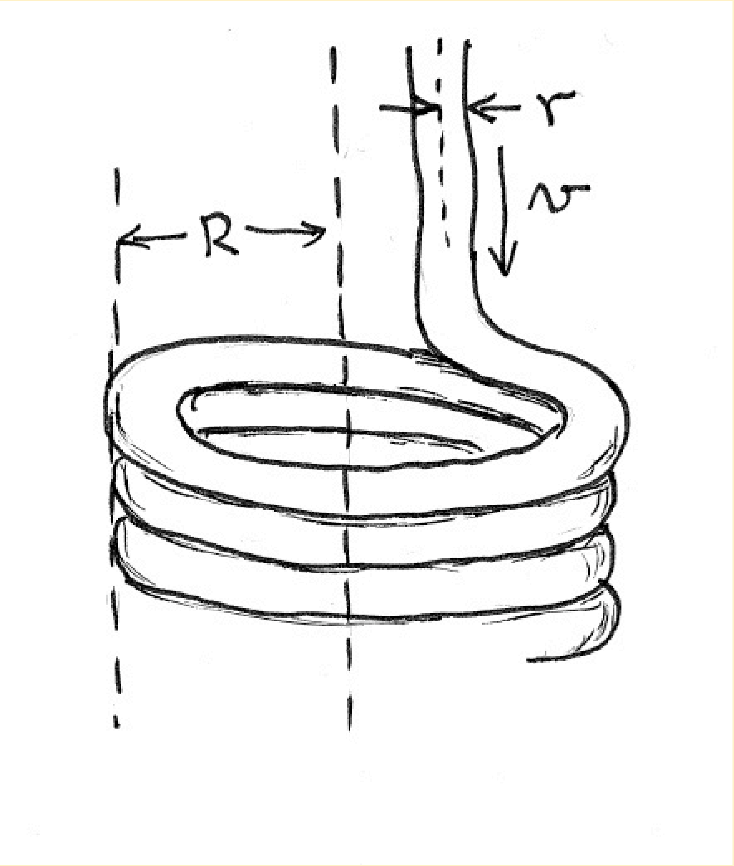
Mahadevan, Ru & Samuel, Nature **392**, 140 (12 March 1998)

Likely variables

rate of flow Q  ($m^3s^{-1}$)
viscosity $\nu$  ($m^2s^{-1}$)
filament radius r  (m)
frequency of laying down the coils $\Omega$  ($s^{-1}$)

And

coil radius R  (m)
speed of filament falling v ($ms^{-1}$)
{But  $v = \Omega R$  and  $v = Q/\pi r^2$ so R and v can be eliminated in favor of Q, r, and $\Omega$.}




Perhaps density?     Ignore for present.

The authors seek $\Omega = F(\nu, Q, r)$

But $\nu$, Q, and r involve only length and time.

Dimensional analysis gives only two equations

for three unknown exponents - **No unique answer!**

Noting that $Q/\nu r$ is dimensionless, we can **at best** write

$$\Omega = Q/r^3\, G(Q/\nu r)$$

Where G(x) is an (as yet) unknown function.

# We need physical input.

The authors argue that the **torque** from **differential viscous force** across the curving strand **balances** the **torque** from the **centrifugal force.**

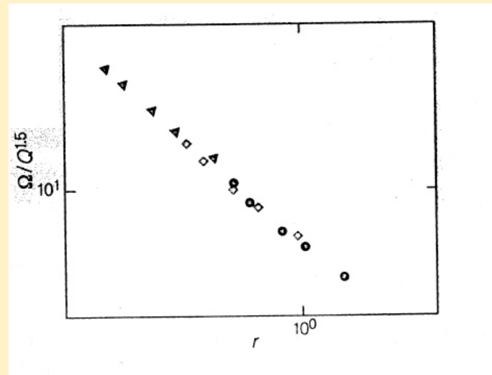
This balancing of torques leads them directly to the relation,

$$\Omega = Q^{4/3} r^{-10/3} \nu^{-1/3}$$

[ equivalent to $G(x) \propto x^{1/3}$ from the previous slide ]

Actually, the authors had in their original paper the formula, $\Omega = Q^{3/2} r^{-7/2} \nu^{-1/2}$ , equivalent to G G(x) $\propto x^{1/2}$. They showed the following plot:

Log-log plot of $\Omega/Q^{3/2}$ vs r

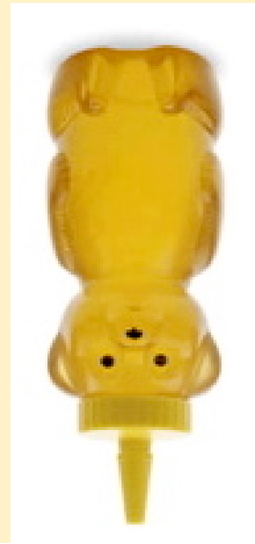


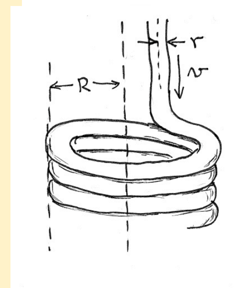

Data follow a power law, , $\Omega/Q^{3/2} \propto r^{-3.58\pm0.16}$
In the **Feb 3/ 2000 revision**, they state that if the data are reanalyzed, a plot of $\Omega/Q^{4/3}$ gives

$$\Omega/Q^{4/3} \propto r^{-3.45\pm0.10}$$

The exponent -3.45 is in poorer agreement with the expected -10/3 than was the original -3.58 with the expected 7/2 . Perhaps they were right the first time.

Honey
Does
Fall
In
Spiral
Coils!

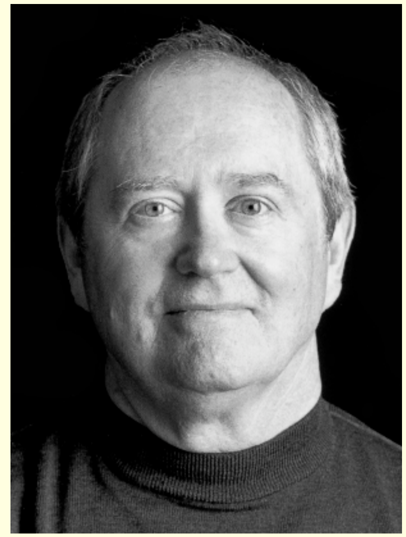




Happy Birthday, Chris and Many Happy Returns !

Alles Gute zum Geburtstag ! Joyeux anniversaire !
Buon compleanno ! Feliz compleaños !
Zorionak zuri !

And
Merry Christmas !



Do you recognize him now?

In case you get bored in some of the talks, here is a problem in dimensional analysis, simpler than falling honey.

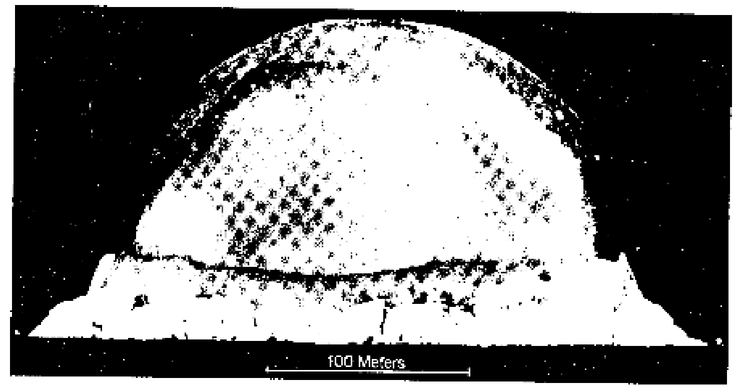



**Figure 10.8** The first atomic explosion, the "Trinity Test," on July 16, 1945, at Jornada del Muerto, near Alamogordo, New Mexico. A fortieth of a second has passed since the start of the explosion. (Los Alamos Scientific Laboratory.)

In July 1945 the first prototype nuclear weapon was exploded in New Mexico. Here is a photo from the files, copied from a book by Emilio Segrè.
We are given the scale on the photo and its time after detonation. The shock front is sharply marked.

Question: What is the energy E of the explosion ?
We know the radius at time t = 25 ms.
We want an equation for the fireball radius R(t) in terms of E and other variables.