

EINSTEIN

Zählen und Erzählen

Vorführung in Form einer
Unterrichtsstunde

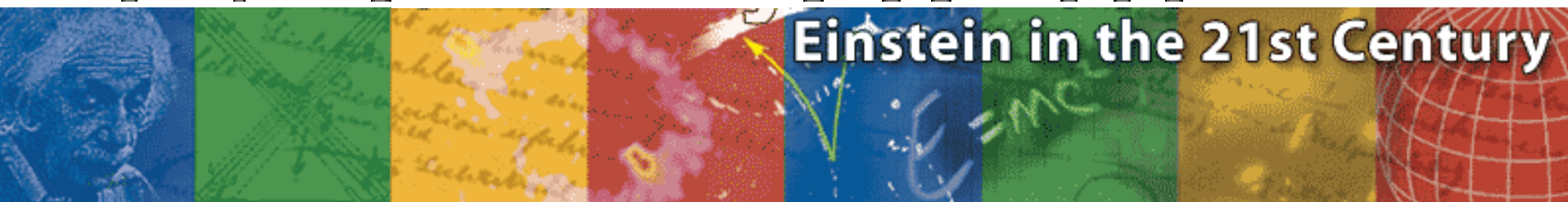
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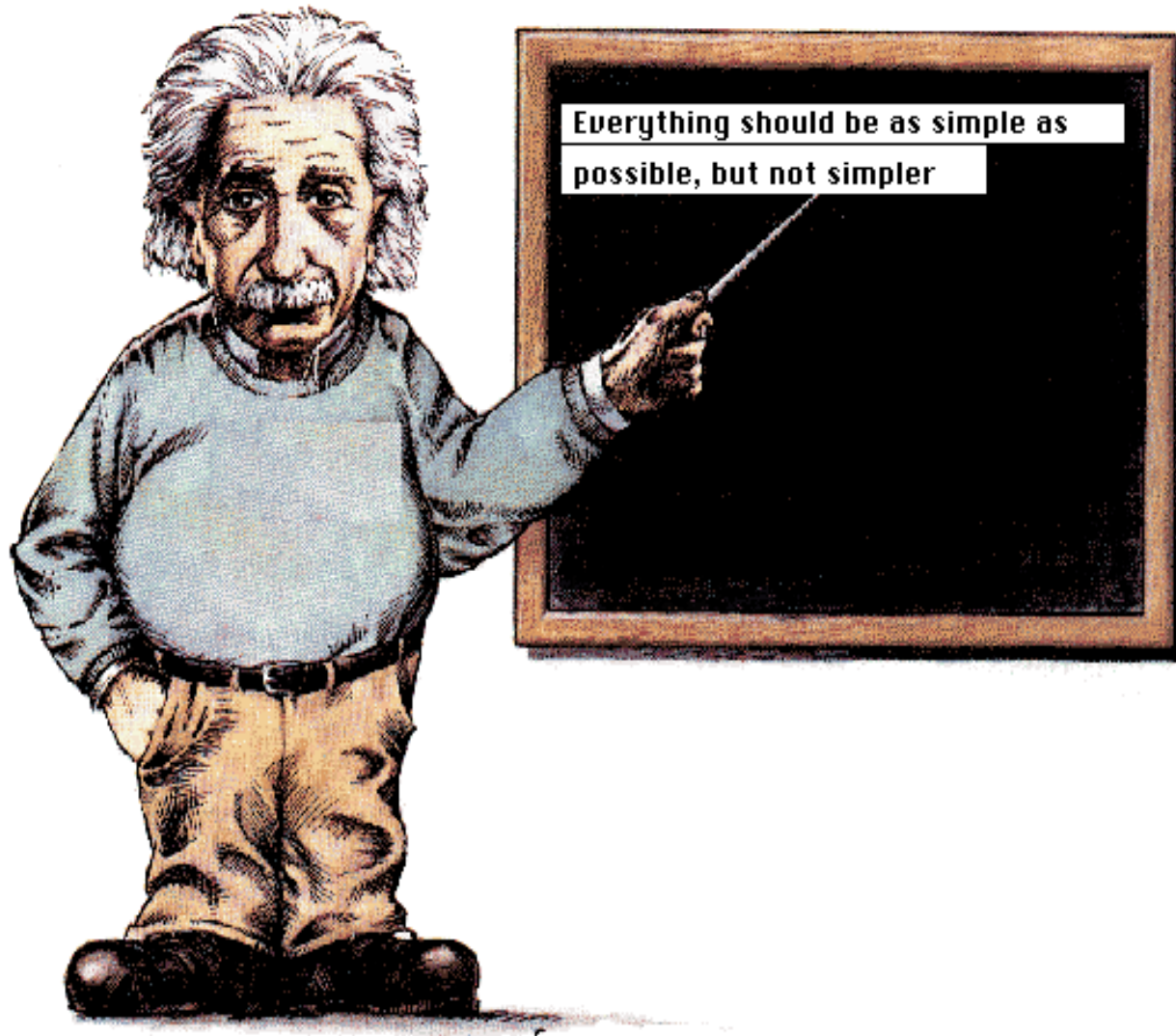
Zählen und Erzählen

Unterrichtsstunde

in Form einer **Vorführung**

World Year of Physics 2005





so einfach wie möglich . . .

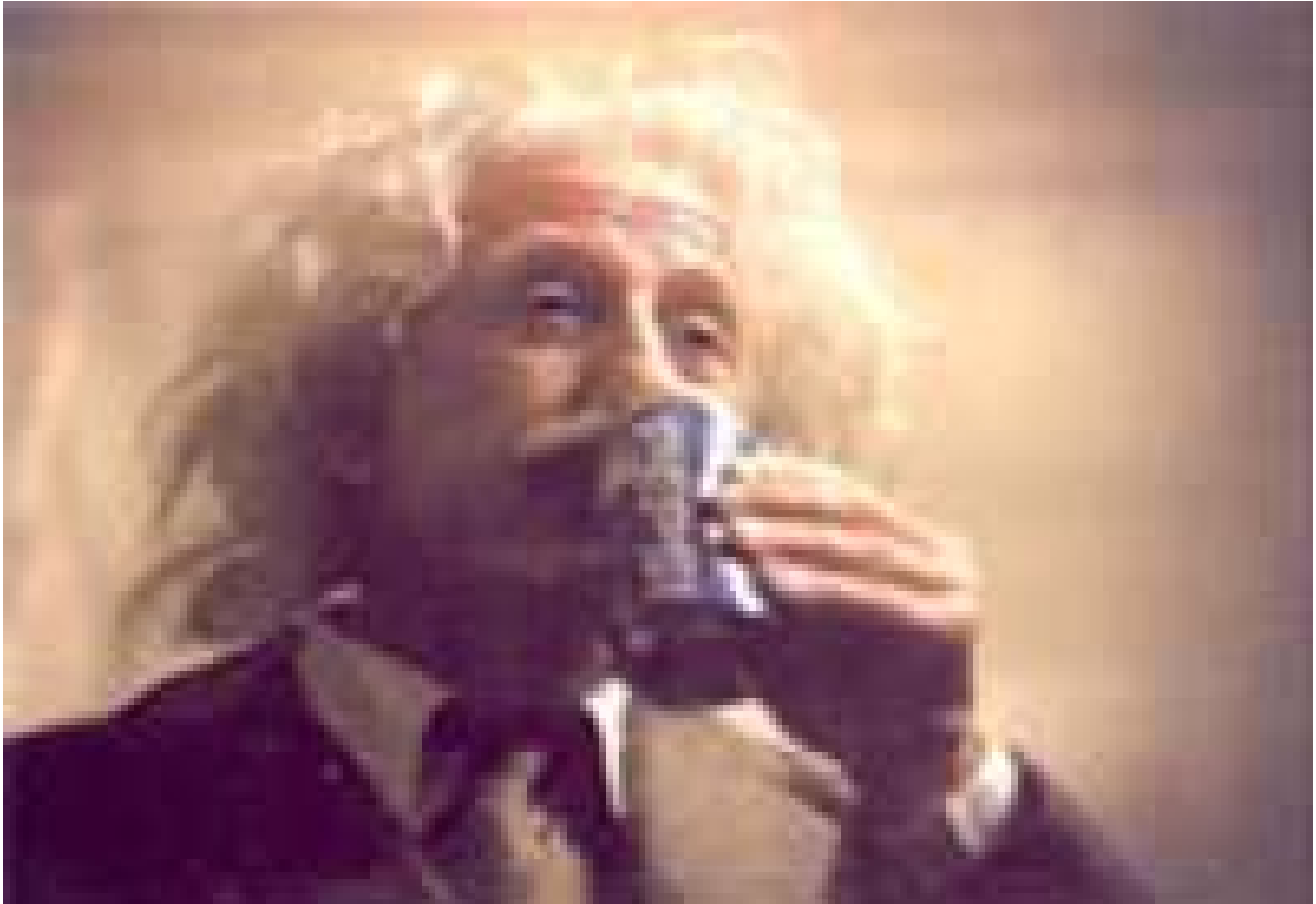
Zur Elektrodynamik Bewegte Körper

Annalen der Physik , 17 , 1905

Werbung



Werbung



Werbung



ZEHN TAFELN DER RELATIVEN SPIEGELUNGEN





***Eine große Entdeckung bedeutet
nicht neues Land,
sondern neue Augen***



An – Abwesende..



Florida



Colorado

DER TANZ DER MASSE

träge

leicht

mobil

schwer

DAS LIED DER ENERGIE

Elektrisch, mechanisch und thermisch.

Und tausend Namen noch / sie ist es aber doch.

Hydraulisch, pneumatisch und chemisch.

Und tausend Namen noch / sie ist es aber doch.

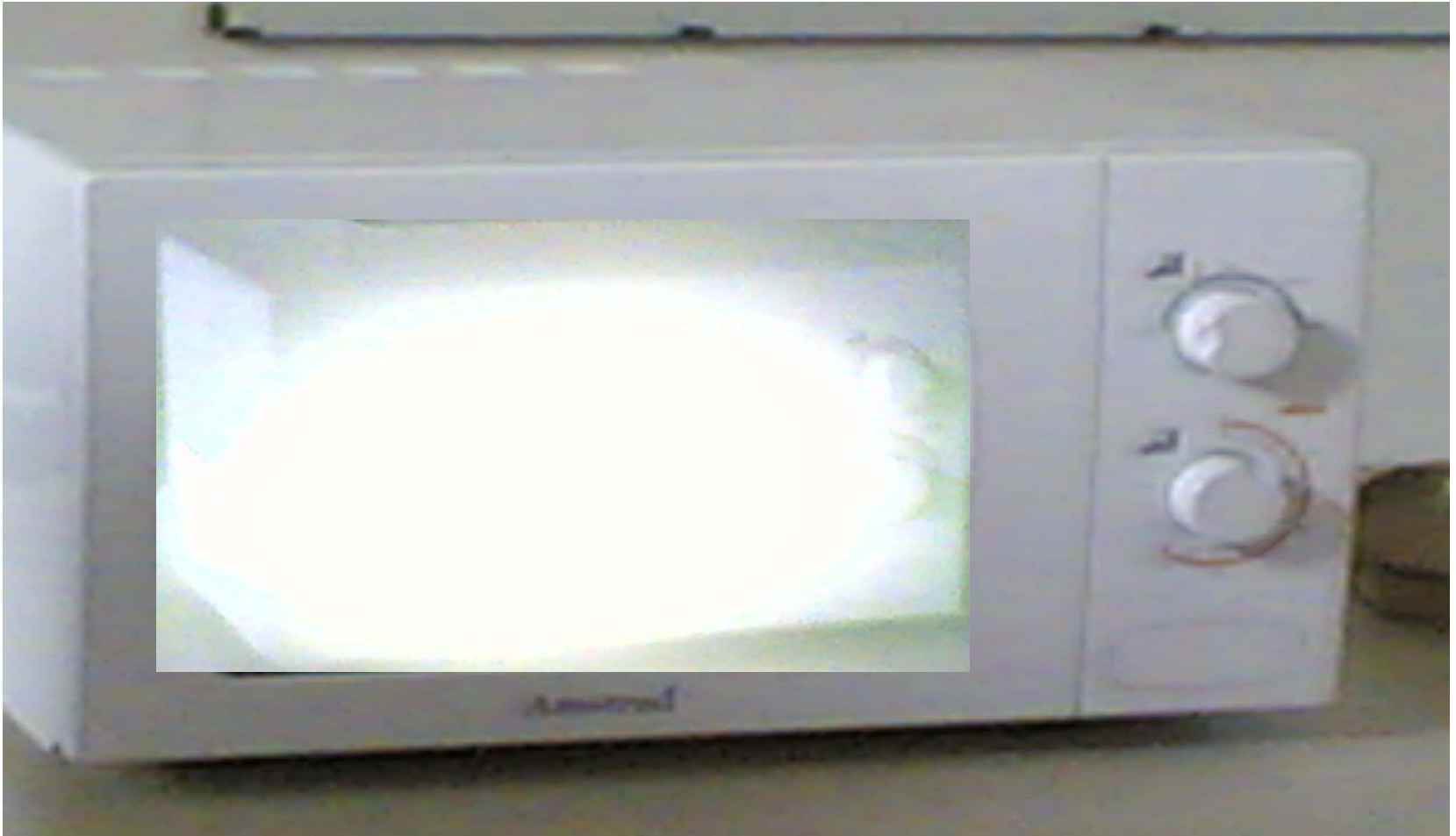
Atomisch, magnetisch und quantisch.

Und tausend Namen noch / sie ist es aber doch.

Elastisch, kinetisch und physisch.

Und tausend Namen noch / sie ist es aber doch.

DIE UMWANDLUNGEN DER ENERGIE



It followed from the special theory of relativity that mass and energy are both but different manifestations of the same thing, a somewhat unfamiliar conception for the average mind. Furthermore, the equation $E = mc^2$ is equal to mass, multiplied by the square of the velocity of light, showed that a very small amount of mass may be converted into a very large amount of energy and viceversa. The mass and energy were in fact equivalent, according to the formula mentioned above. This was demonstrated by Cockcroft and Walton in 1932 experimentally.



MASSE

SKALAR

POSITIV

EXTENSIV

MENGENARTIG

STRÖMEND

ERHALTEN

INVARIANT

ENERGIE

SKALAR

POSITIV

EXTENSIV

MENGENARTIG

STRÖMEND

ERHALTEN

¿NICHT INVARIANT ?

DIE EINSTEINSCHES KONSTANTE

$$\text{Energie} = K_{\text{Einstein}} \text{ Masse}$$

$$K_{\text{Einstein}} = 9 \cdot 10^{16} \text{ J/kg}$$

REVOLUTION IN SCIENCE.

NEW THEORY OF THE UNIVERSE.

* NEWTONIAN IDEAS OVERTHROWN.

Yesterday afternoon in the rooms of the Royal Society, at a joint session of the Royal and Astronomical Societies, the results obtained by British observers of the total solar eclipse of May 29 were discussed.

The greatest possible interest had been aroused in scientific circles by the hope that rival theories of a fundamental physical problem would be put to the test, and there was a very large attendance of astronomers and physicists. It was generally accepted that the observations were decisive in the verifying of the prediction of the famous physicist, Einstein, stated by the President of the Royal Society as being the most remarkable scientific event since the discovery of the predicted existence of the planet Neptune. But there was difference of opinion as to whether science had to face merely a new and unexplained fact, or to reckon with a theory that would completely revolutionize the accepted fundamentals of physics.

SIR FRANK DYSON, the Astronomer Royal, described the work of the expeditions sent respectively to Sobral in North Brazil and the island of Principe, off the West Coast of Africa. At each of these places, if the weather were propitious on the day of the eclipse, it would be possible to take during totality a set of photographs of the obscured sun and of a number of bright stars which happened to be in its immediate vicinity. The desired object was to ascertain whether the light from these stars, as it passed the sun, came as directly towards us as if the sun were not there, or if there was a deflection due to its presence, and if the latter proved to be the case, what the amount of the deflection was. If deflection did occur, the stars would appear on the photographic plates at a measurable distance from their theoretical positions. He explained in detail the apparatus that had been employed, the corrections that had to be made for various disturbing factors, and the methods by which comparison between the theoretical and the observed positions had been made. He convinced the meeting that the results were definite and conclusive. Deflection did take place, and the measurements showed that the extent of the deflection was in close accord with the theoretical degree predicted by Einstein, as opposed to half that degree, the amount that would follow from the principles of Newton. It is interesting to recall that Sir Oliver Lodge, speaking at the Royal Institution last February, had also ventured on a prediction. He doubted if deflection would be observed, but was confident that if it did take place, it would follow the law of Newton and not that of Einstein.

DR. CROMBIE and PROFESSOR EDDINGTON, two of the actual observers, followed the Astronomer Royal, and gave interesting accounts of their work, in every way confirming the general conclusions that had been enunciated.

"MOMENTOUS PRONOUNCEMENT."

So far the matter was clear, but when the discussion began, it was plain that the scientific interest centred more in the theoretical bearings of the results than in the results themselves. Even the President of the Royal Society, in stating that they had just listened to "one of the most momentous, if not the most momentous, pronouncements of human thought," had to confess that no one had yet succeeded in stating in clear language what the theory of Einstein really was. It was accepted, however, that Einstein, on the basis of his theory, had made three predictions. The first, as to the motion of the planet Mercury, had been verified. The second, as to the existence and the degree of deflection of light as it passed the sphere of influence of the sun, had now been verified. As to the third, which depended on spectroscopic observations there was still uncertainty. But he was confident that the Einstein theory must now be reckoned with, and that our conceptions of the fabric of the universe must be fundamentally altered.

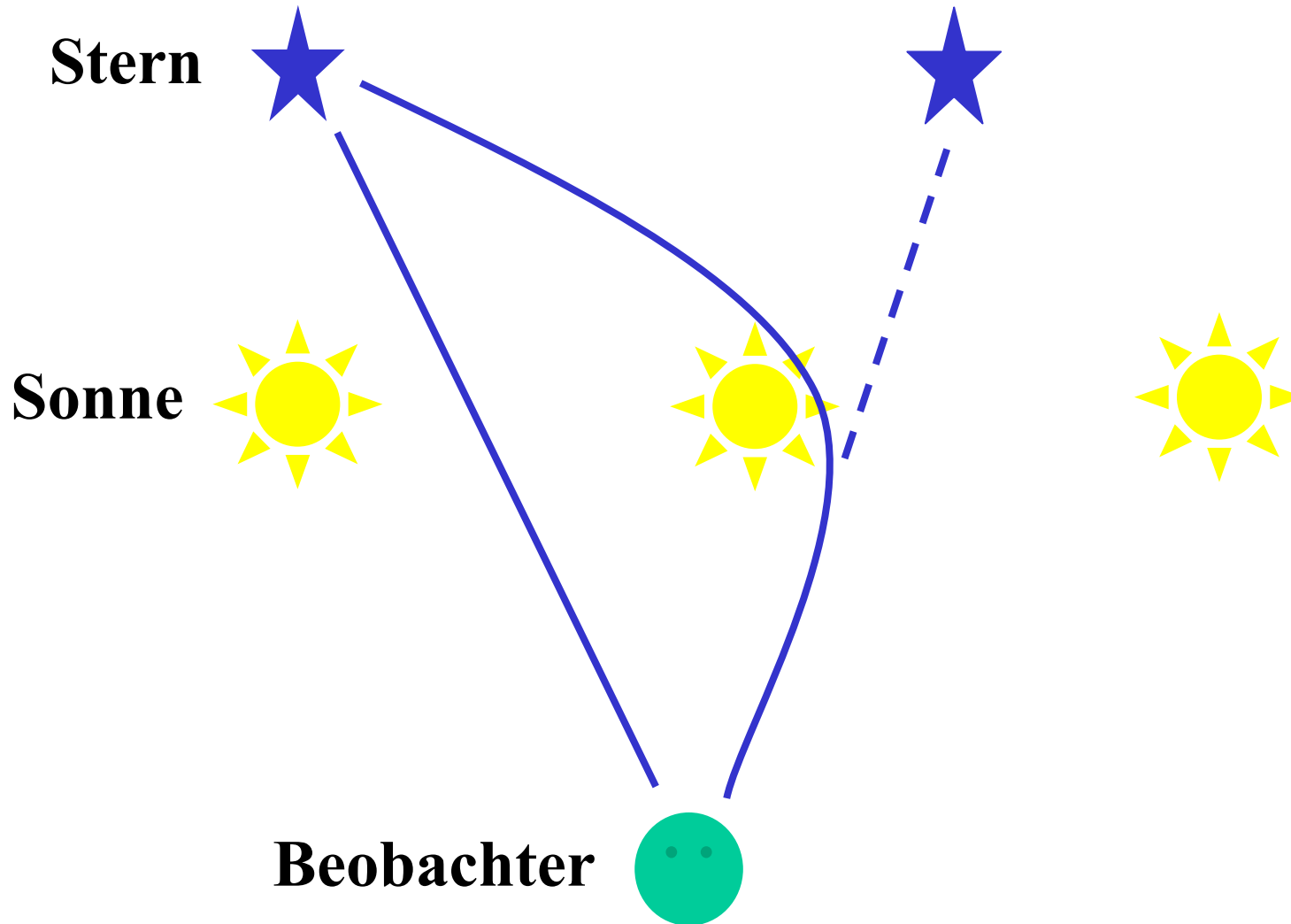
At this stage Sir Oliver Lodge, whose contribution to the discussion had been eagerly expected, left the meeting.

Subsequent speakers joined in congratulating the observers, and agreed in accepting their results. More than one, however, including Professor Newall, of Cambridge, hesitated as to the full extent of the inferences that had been drawn and suggested that the phenomena might be due to an unknown solar atmosphere further in its extent than had been supposed and with unknown properties. No speaker succeeded in giving a clear non-mathematical statement of the theoretical question.

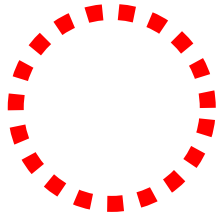
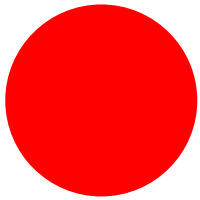
SPACE "WARPED."

Put in the most general way it may be described as follows: the Newtonian principles assume that space is invariable, that, for instance, the three angles of a triangle always equal, and must equal, two right angles. But these principles really rest on the observation that the angles of a triangle do equal two right angles, and that a circle is really circular. But there are certain physical facts that seem to throw doubt on the universality of these observations, and suggest that space may acquire a twist or warp in certain circumstances, as, for instance, under the influence of gravitation, a dislocation in itself slight and applying to the instruments of measurement as well as to the things measured. The Einstein doctrine is that the qualities of space, hitherto believed absolute, are relative to their circumstances. He drew the inference from his theory that in certain cases actual measurement of light would show the effects of the warping in a degree that could be predicted and calculated. His predictions in two of three cases have now been verified, but the question remains open as to whether the verifications prove the theory from which the predictions were deduced.

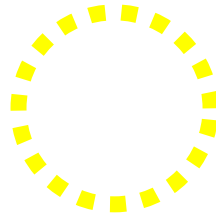
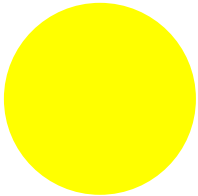
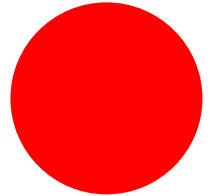
DIE VERSCHIEBUNG DER FIXSTERNE



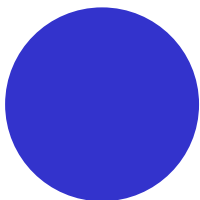
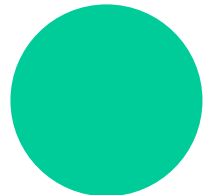
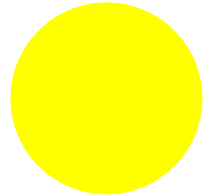
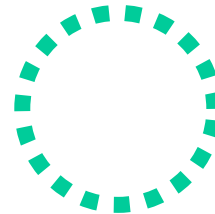
ANSTIEG UND ABSTIEG DES LICHTES



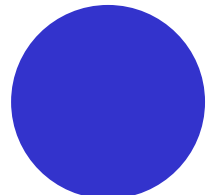
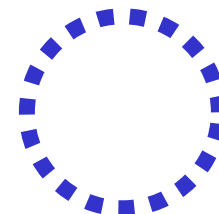
$$\Delta f_{\text{rot blau}} \approx 4 \cdot 10^{-7} \text{ Hz}$$



$$\frac{\Delta f}{f} = \frac{g}{c^2} \Delta h \approx 10^{-15}$$



$$\Delta h_{\text{hoch tief}} \approx 10 \text{ m}$$



DER GEWICHTSUNTERSCHIED ZWISCHEN EINER **VOLLEN** UND EINER **LEEREN** BATTERIE

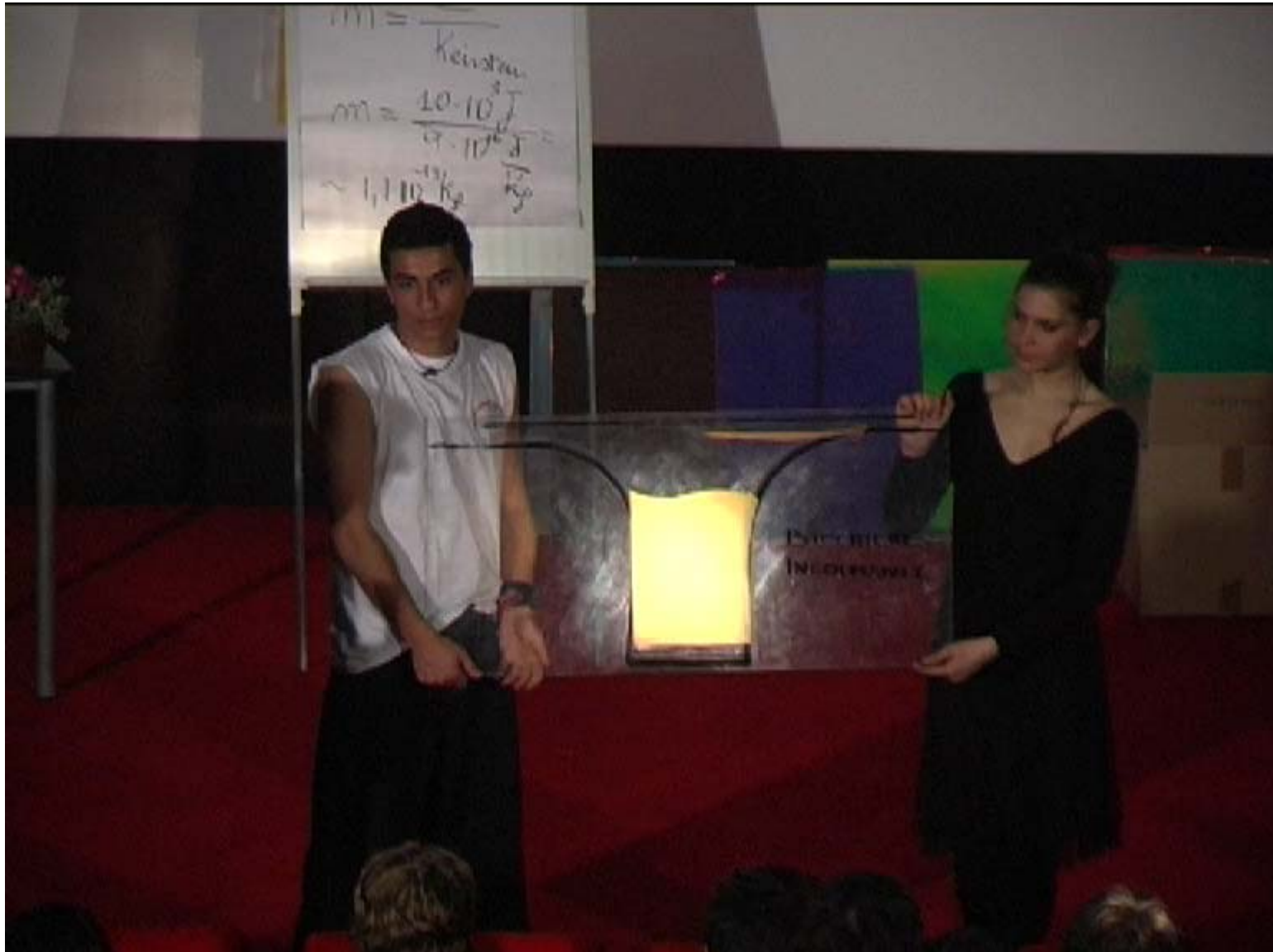
$$10 \text{ kJ} / 9 \cdot 10^{16} \text{ J/kg} =$$

$$1,11 \cdot 10^{-13} \text{ kg}$$

EIN TYPISCHES STAUBKÖRNCHEIN

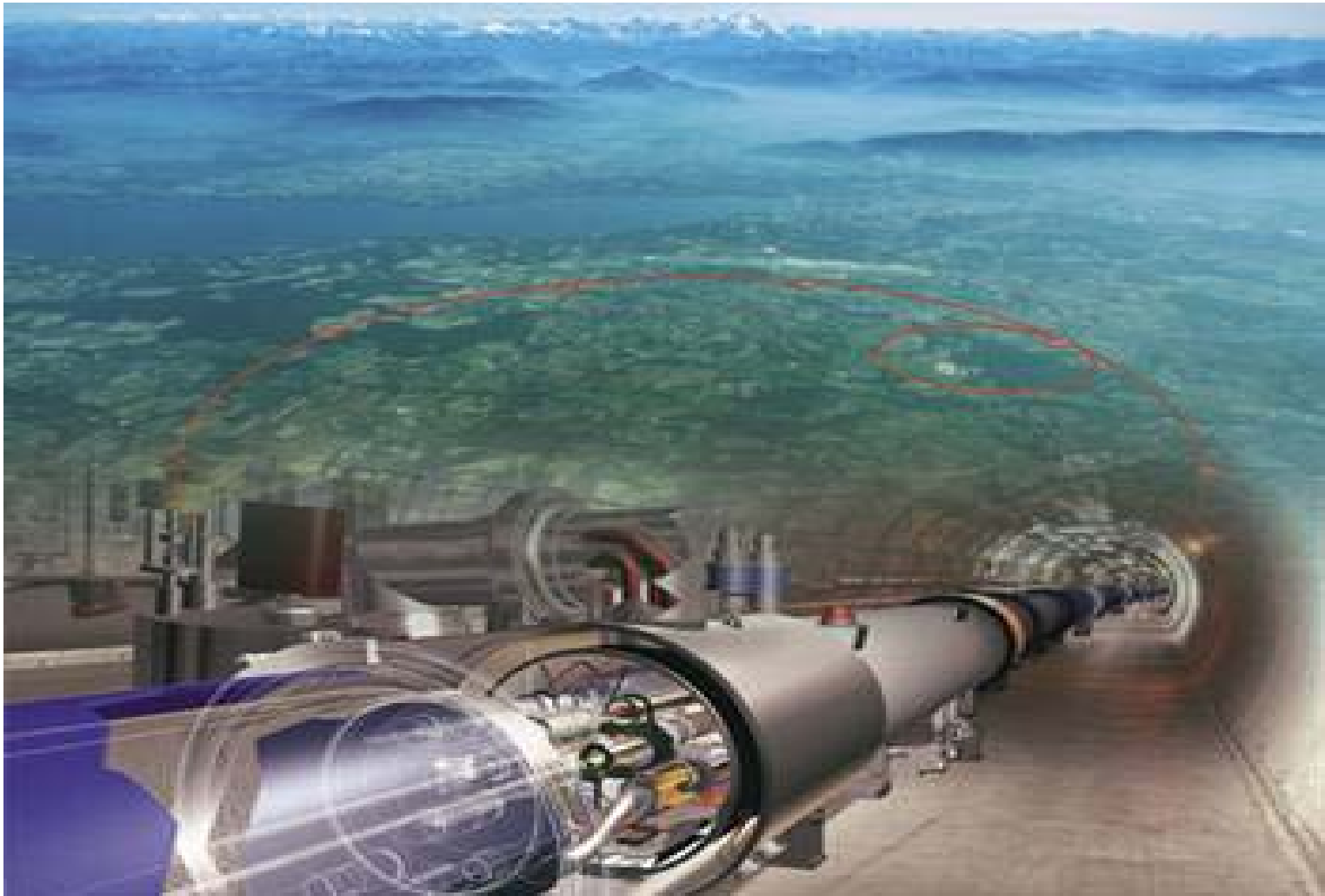
WIEGT ETWA $\sim 10^{-12} \text{ kg}$

DAS UNAUFFÜLLBARE GLAS

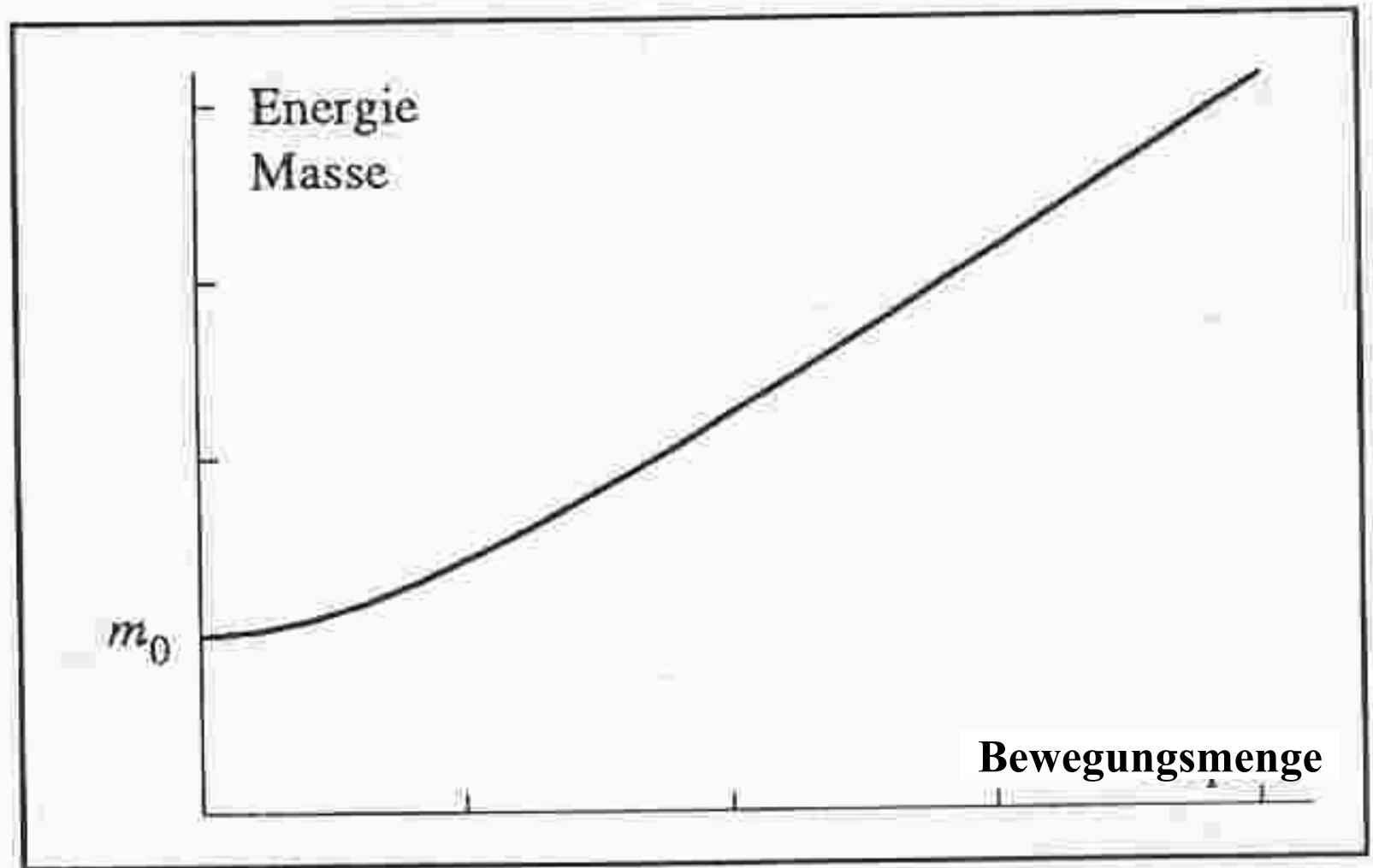


DAS BILDSCHIRM EXPERIMENT

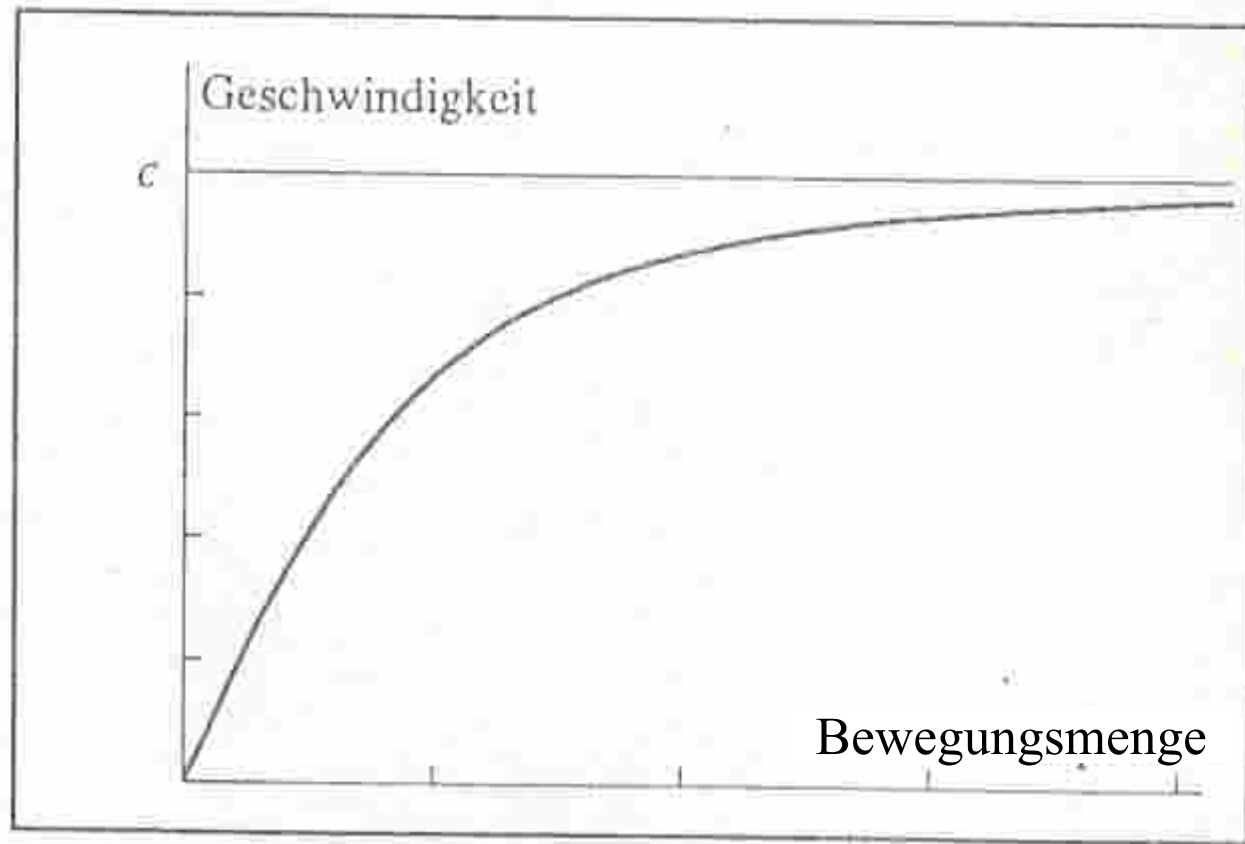
TEILCHENBESCHLEUNIGER



Zusammenhang zwischen Energie und Bewegungsmenge



Zusammenhang zwischen Geschwindigkeit und Bewegungsmenge



DIE FORMEL

$$E = m c^2$$

$$c = \sqrt{K_{Einstein}} = 300000 \text{ km/s}$$

DAS LICHT

ANNÄHERUNG UND ENTFERNUNG



ENERGIE IN EINEM STEIN

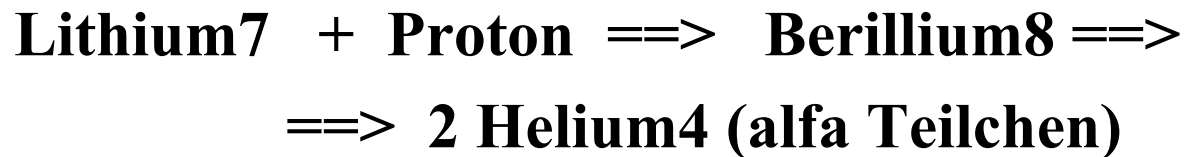
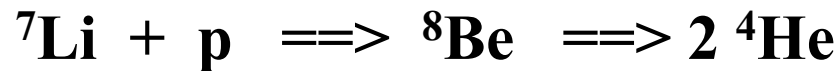
$$E = 1\text{kg} \cdot 9 \cdot 10^{16} \text{ J/kg} =$$

90 Millionen von Billionen J

$$2 \cdot 10^9 \cdot 4,3 \cdot 10^7 \sim 9 \cdot 10^{16}$$

2 Billionen mal die Energie in 1 kg Benzin

**This was demonstrated by
Cockcroft and Walton in 1932
experimentally**



DIE VERBRENNUNG DER MASSE

Materie + Antimaterie $\rightarrow$ Licht

$$\mathbf{p + \tilde{p} \rightarrow 2 \gamma}$$

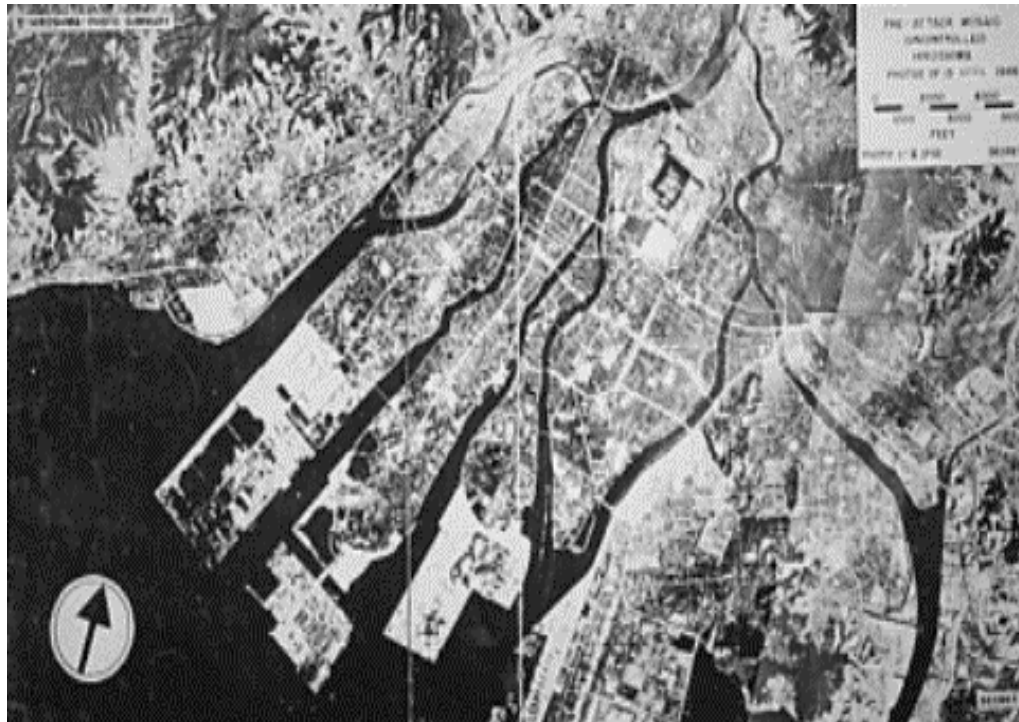
$$\mathbf{2 \times 1,6725 \, 10^{-27} \, Kg \qquad 3,105 \, 10^{-18} \, J}$$

Antiproton Portable Trap



NASA

DAS "ÜBEL DER ATOMBOMBE



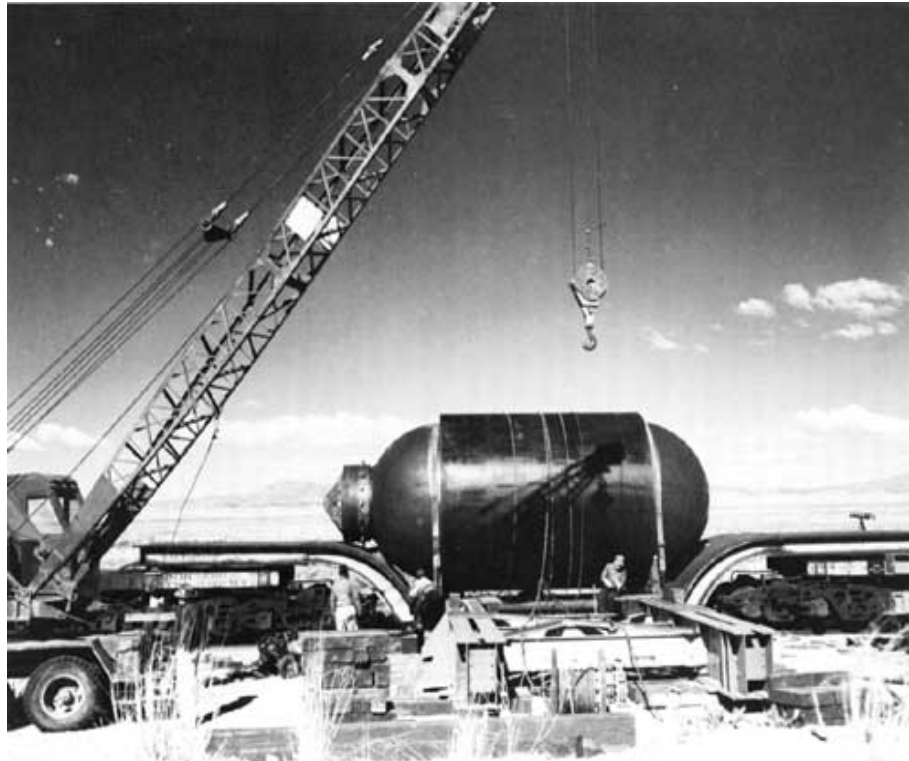
DAS ÜBEL DER ATOMBOMBE



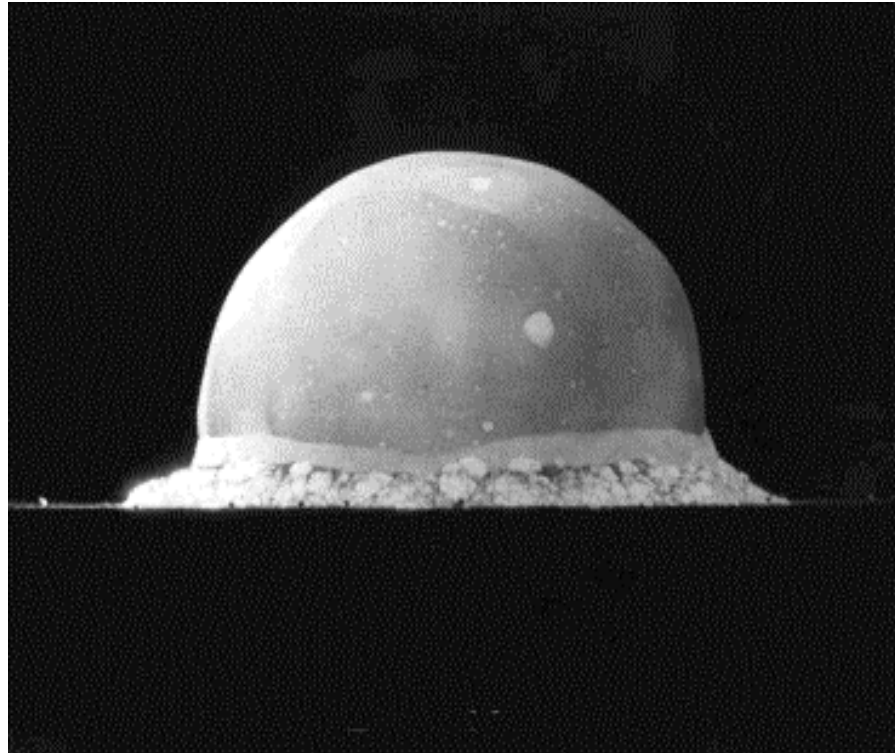
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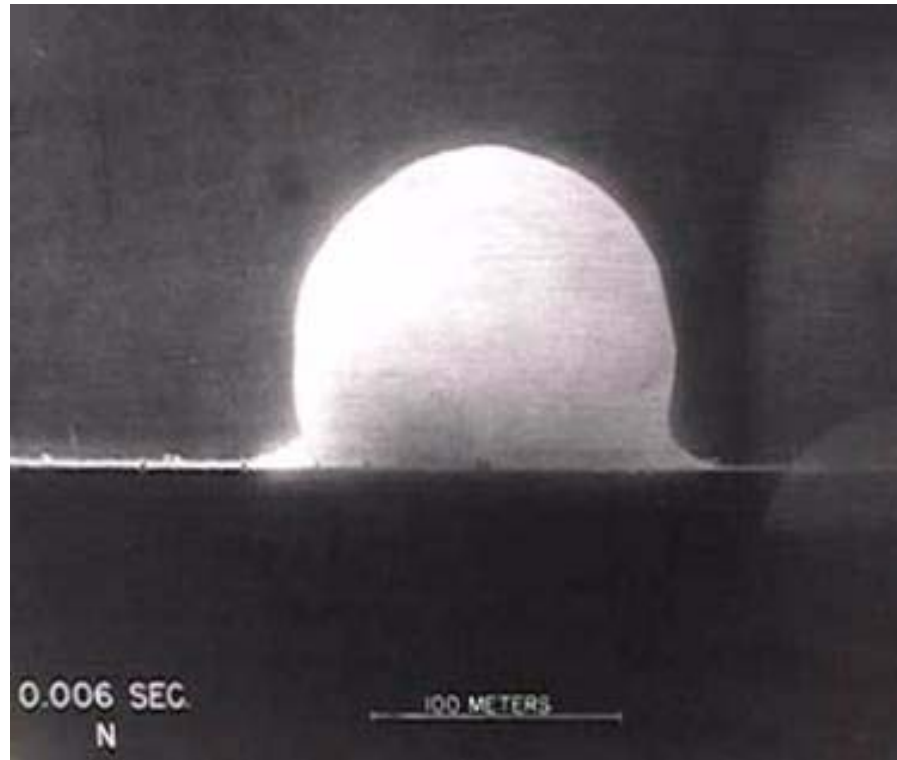
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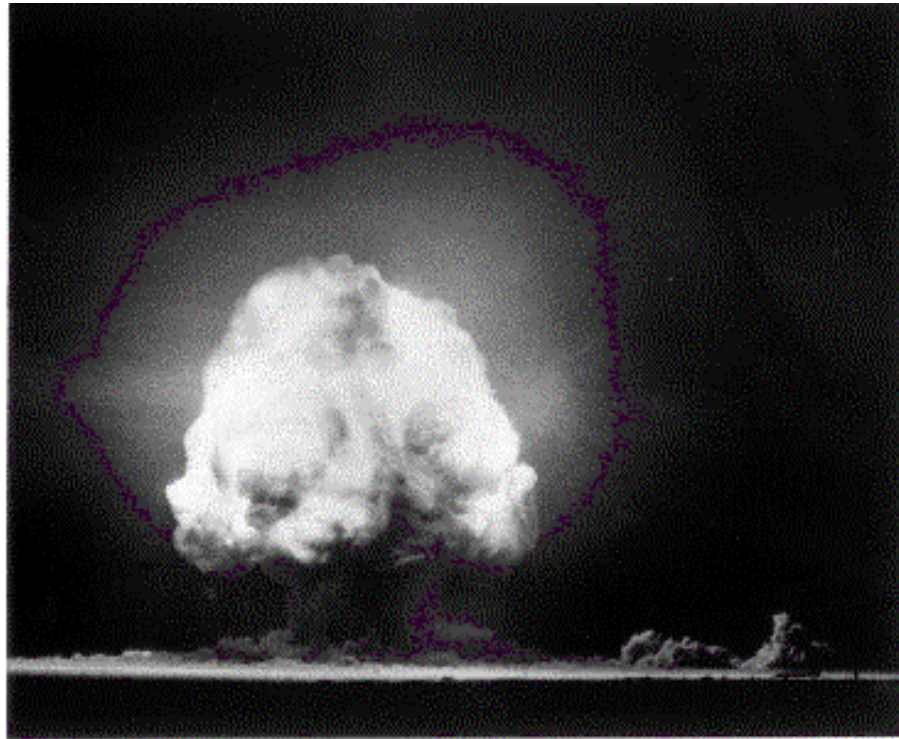
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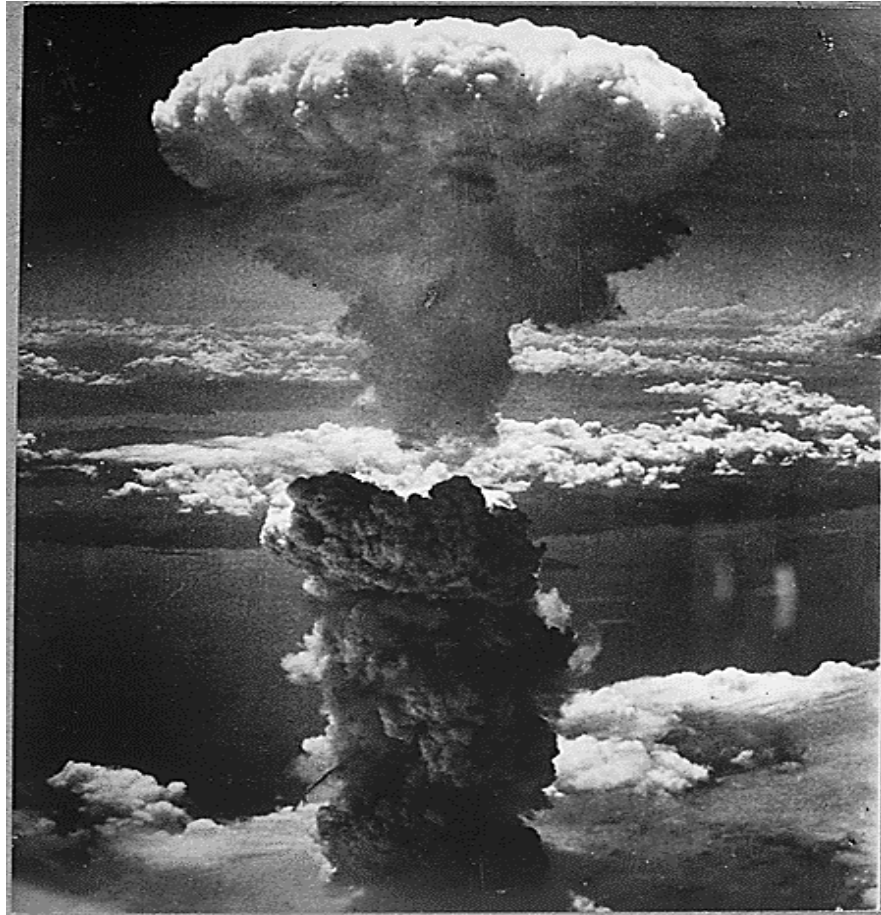
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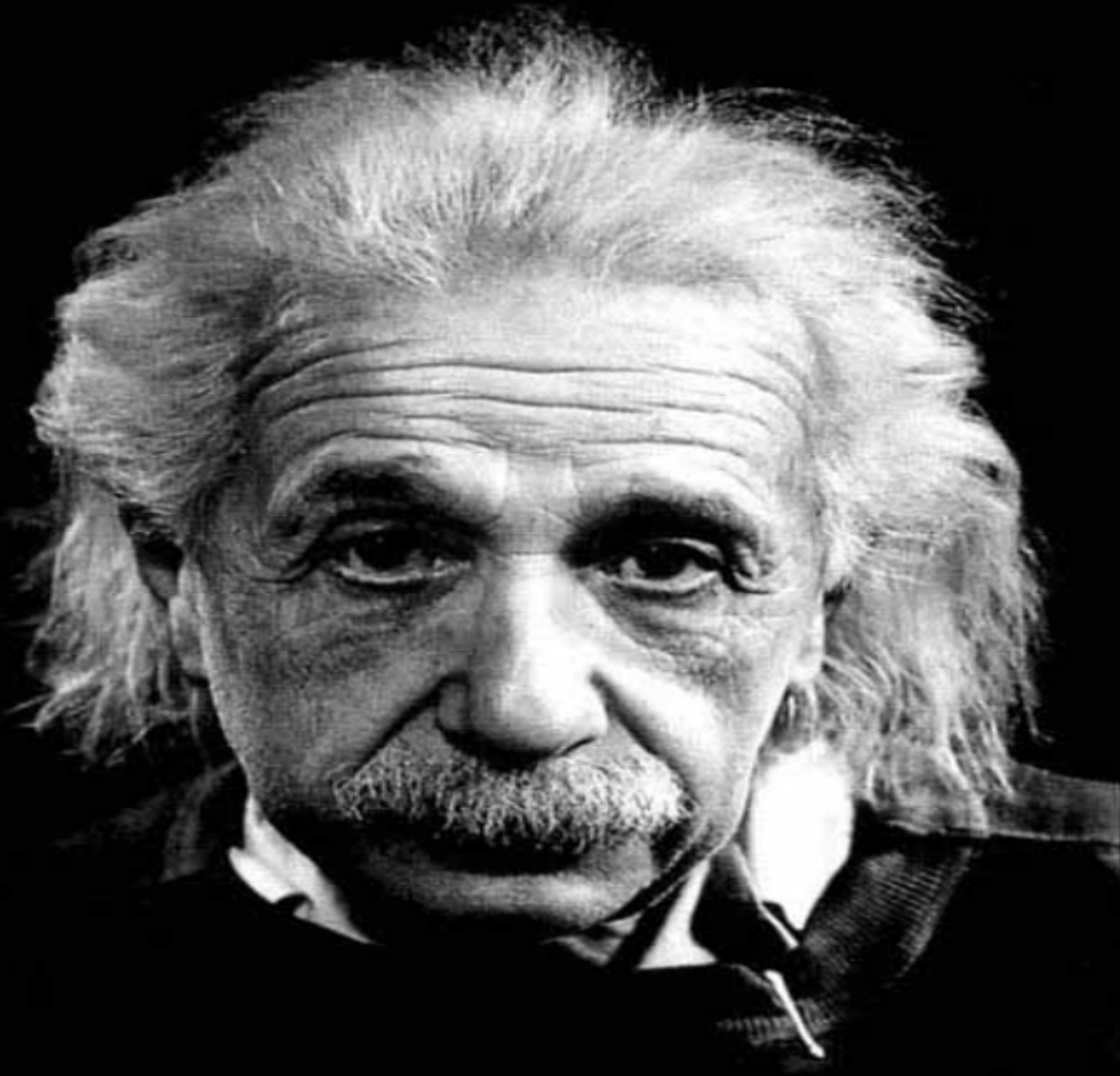


DAS "ÜBEL DER ATOMBOMBE



DAS ÜBEL DER ATOMBOMBE





die Gedanken aus schwierigen Zeiten

DAS WOHL DER KOBALTBOMBE



DER GEDANKEN – LASER

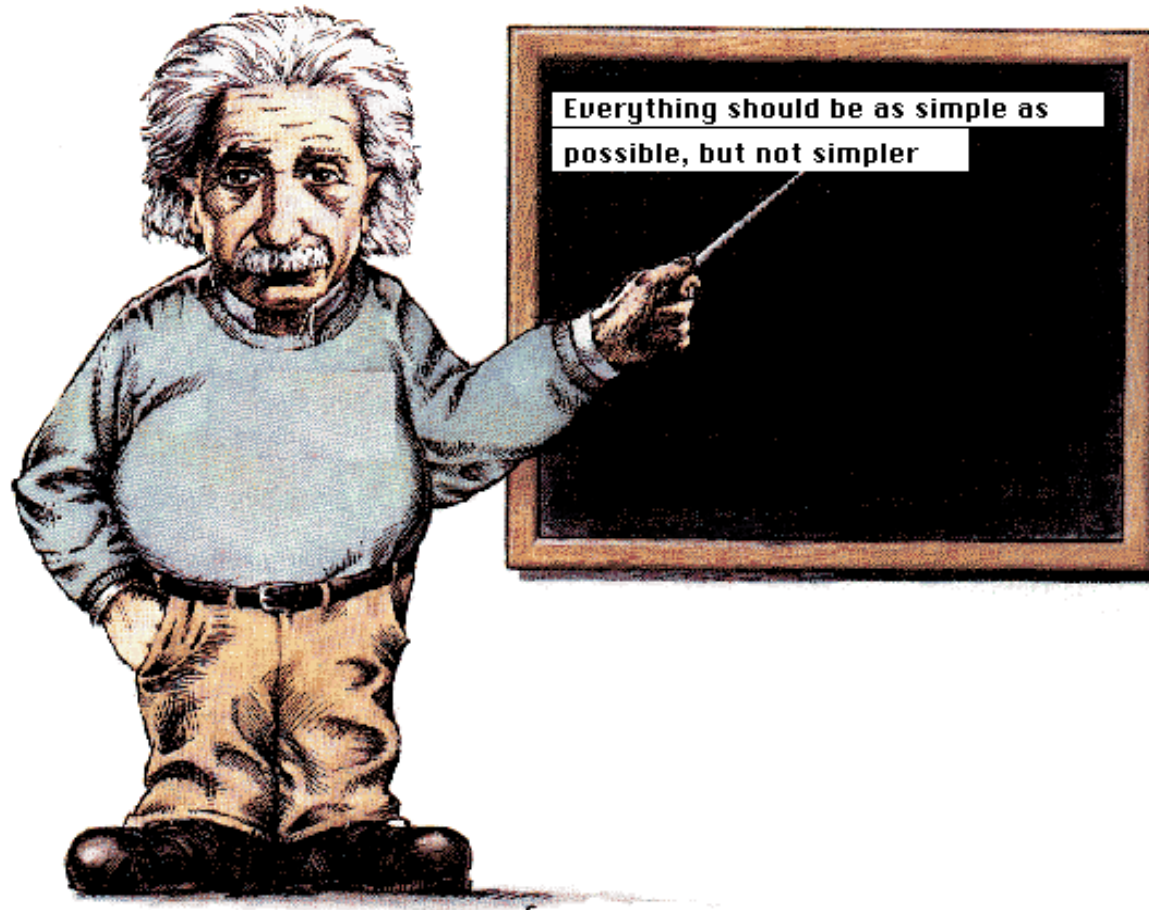


LIGHT
AAMPLIFICATION
BY
SSTIMULATED
EEMISSION
OF
RRADIATION

DAS T – SHIRT

DES IRRTUMS UND DES IRRSINNS





...aber nicht einfacher

**DIE RELATIVITÄT IST
HUNDERT: HÖCHSTE
ZEIT, SIE ZU LERNEN!**

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