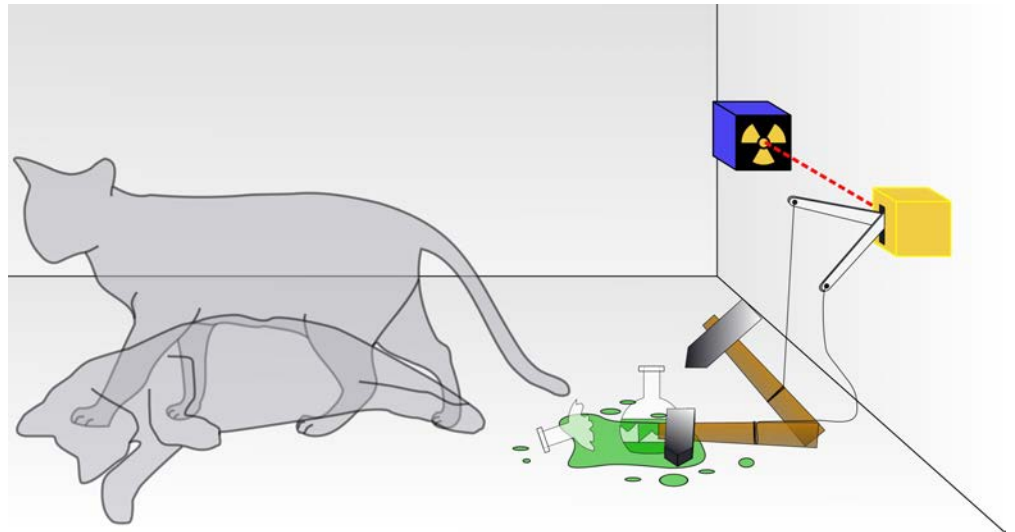
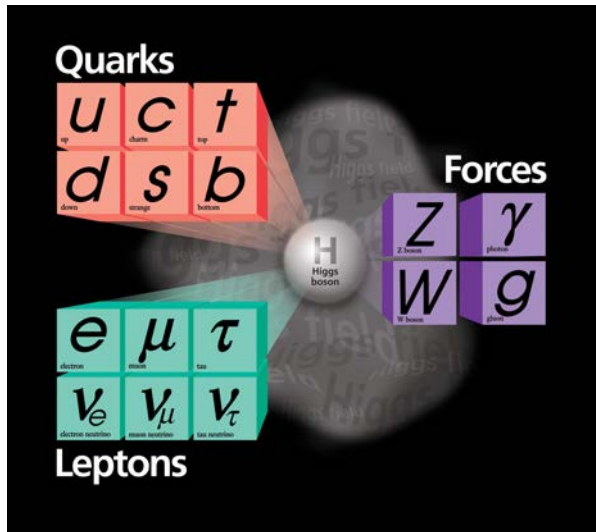


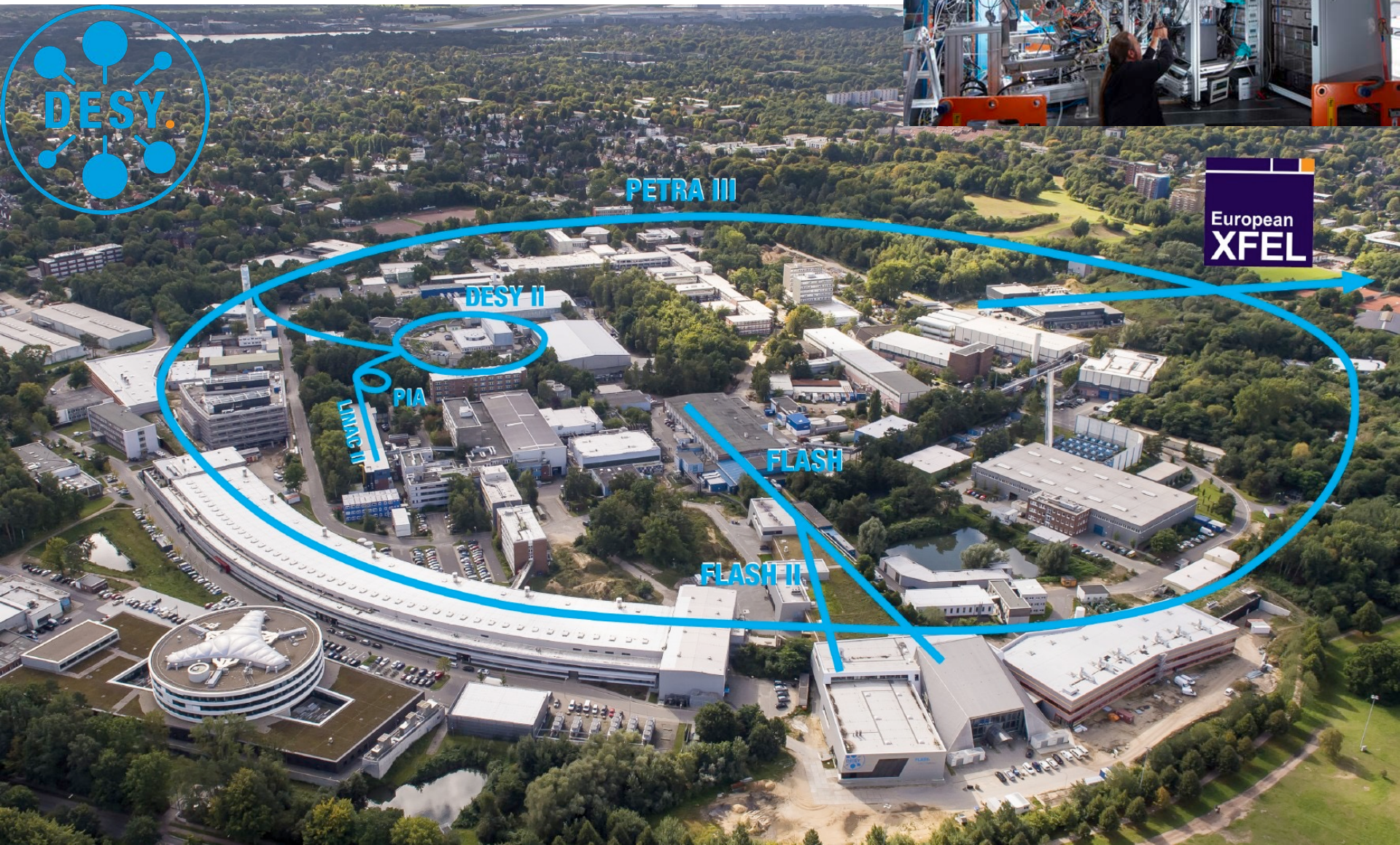
Warum Physik?



SUSTAINABLE DEVELOPMENT GOALS



Abenteuerspielplatz



Literatur I

Teil 1

Einführung

Kapitel 1, S. 1-18

Mechanik

Kapitel 2, S. 19-151

Teil 2

Schwingungen & Wellen

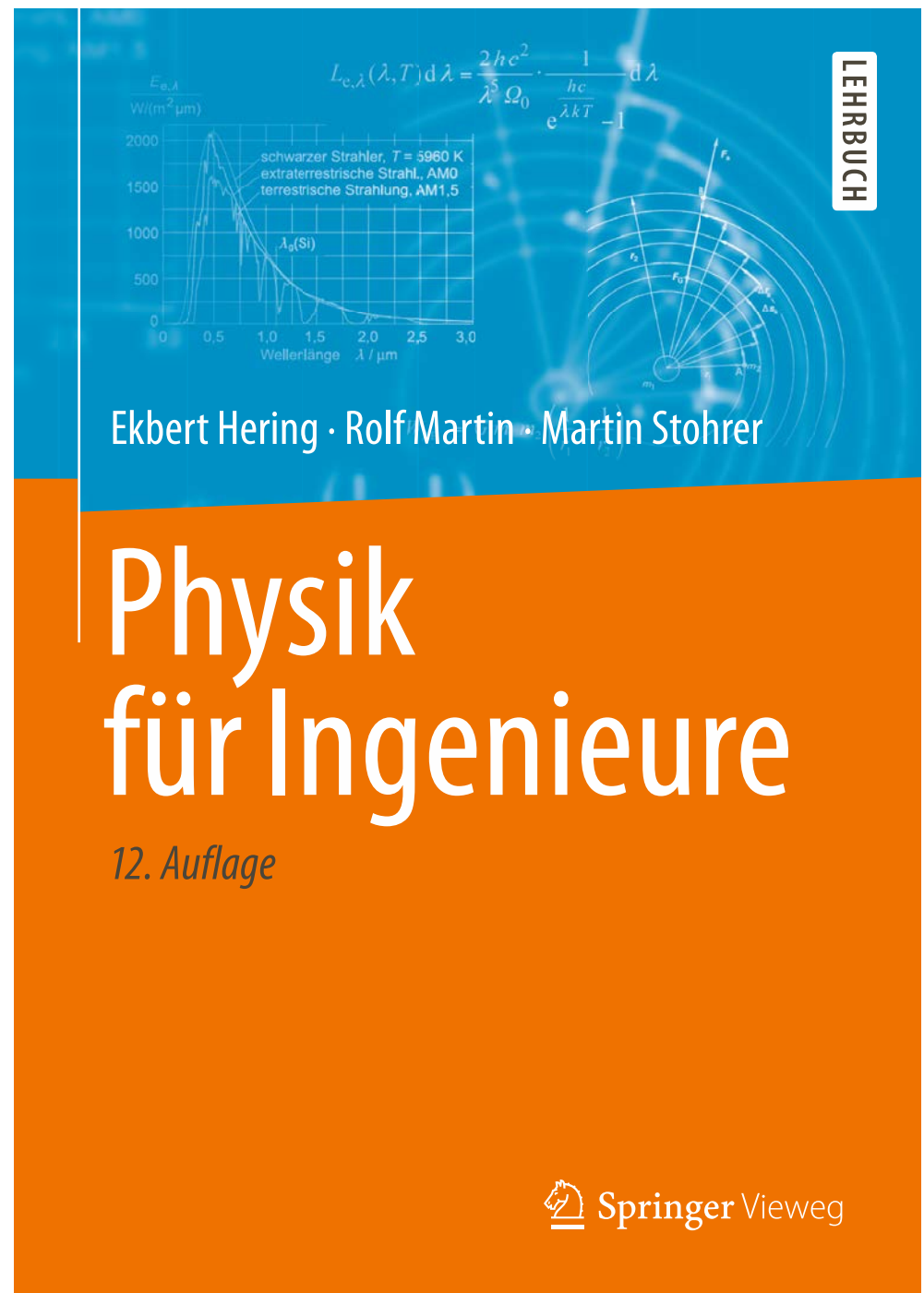
Kapitel 5, S. 377-440

Optik

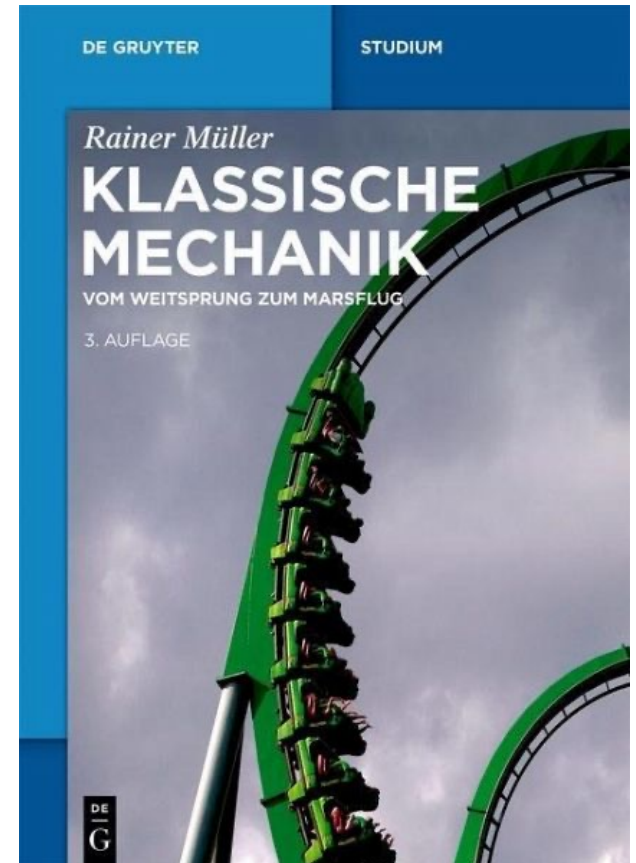
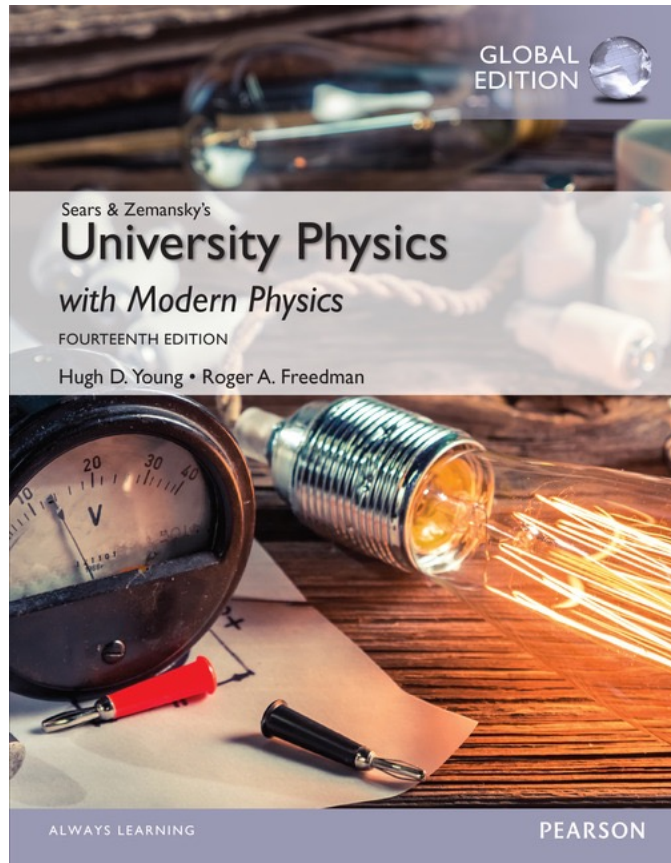
Kapitel 6, S. 441-530(551)

Thermodynamik

Kapitel 3, S. 153-236

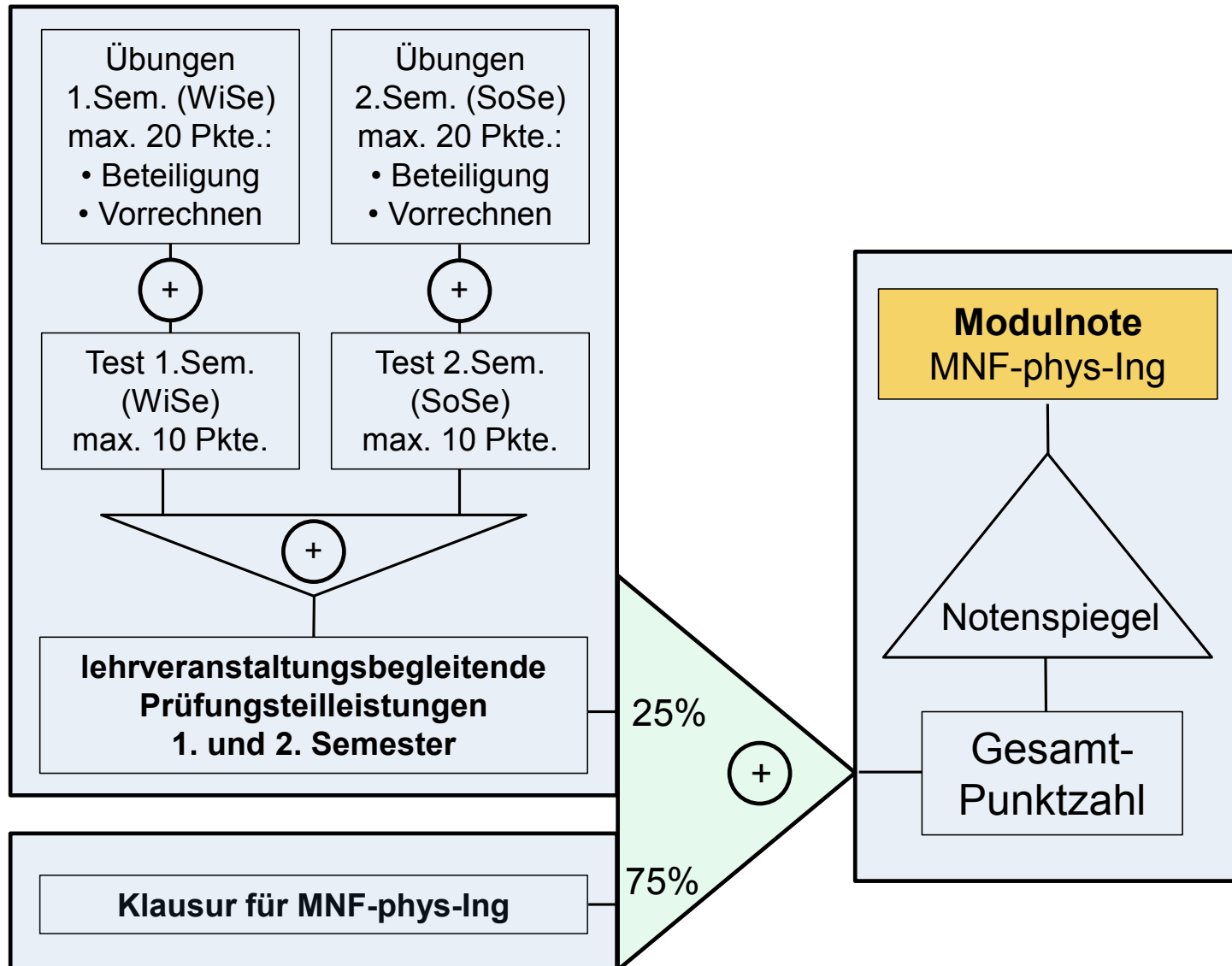


Literatur II



feynmanlectures.caltech.edu/I_toc.html

Prüfungsleistungen



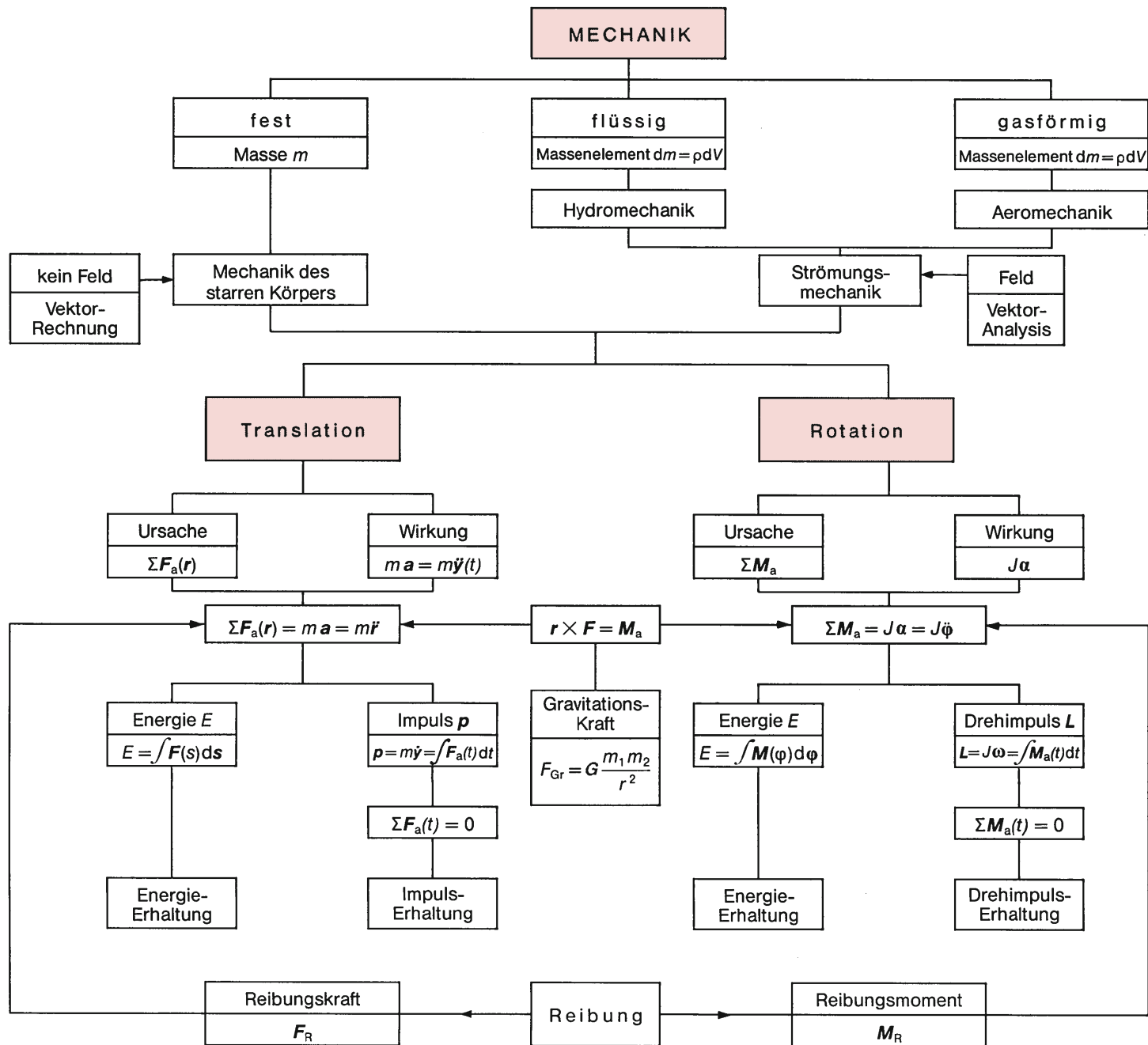


Abb. 2.1 Strukturbild der Mechanik

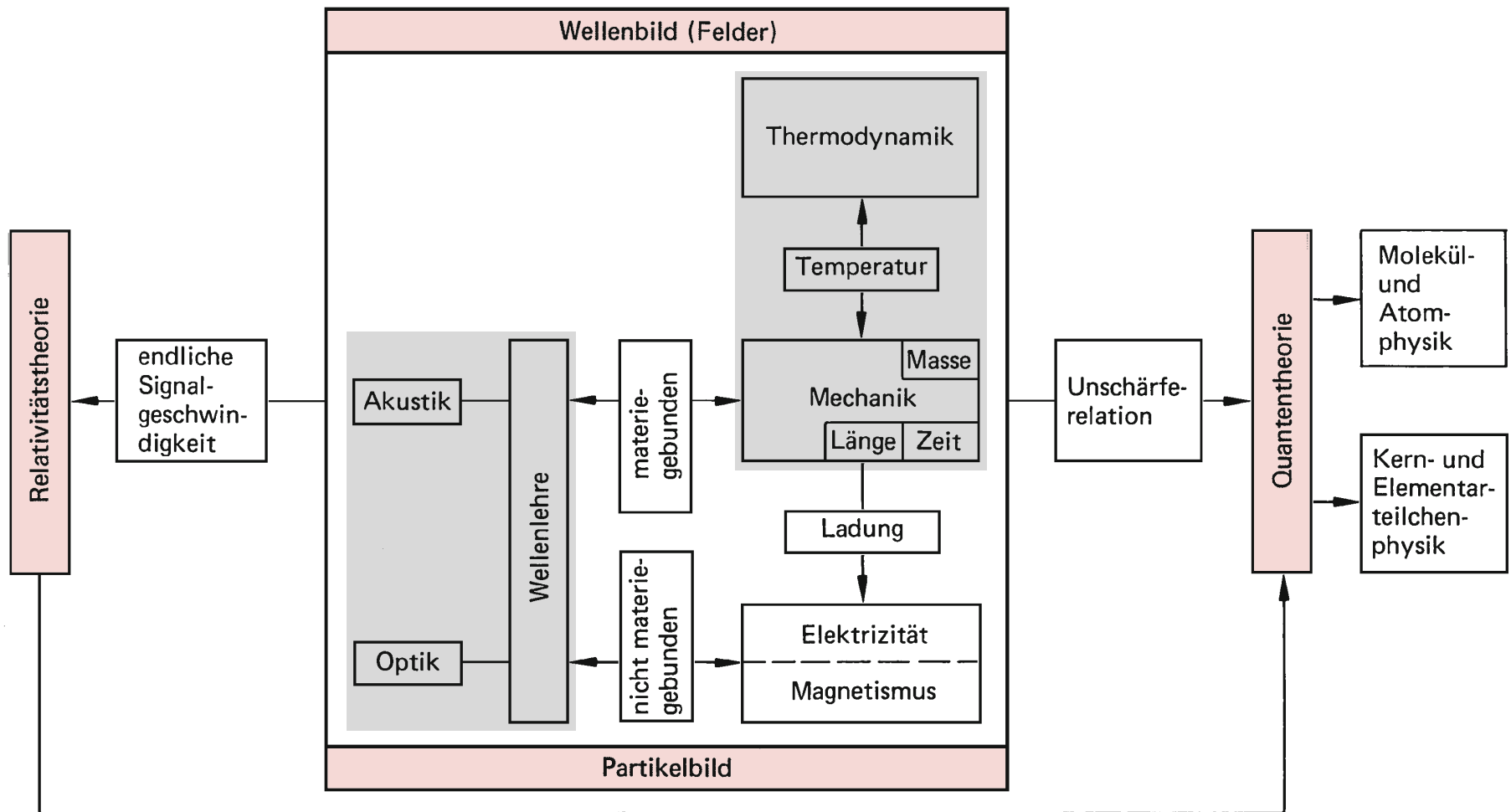


Abb. 1.3 Gebiete der Physik

Quizfrage 1

Welchen Vorsprung hat ein Photon gegenüber einem PETRA III-Positron ($0.99999999964\ c$) bei einem Wettlauf zum Mond ($384400\ \text{km}$)?

- A. ca. 1 mm
- B. ca. 1 m
- C. ca. 1 km
- D. ca. 1000 km

Quizfrage 2

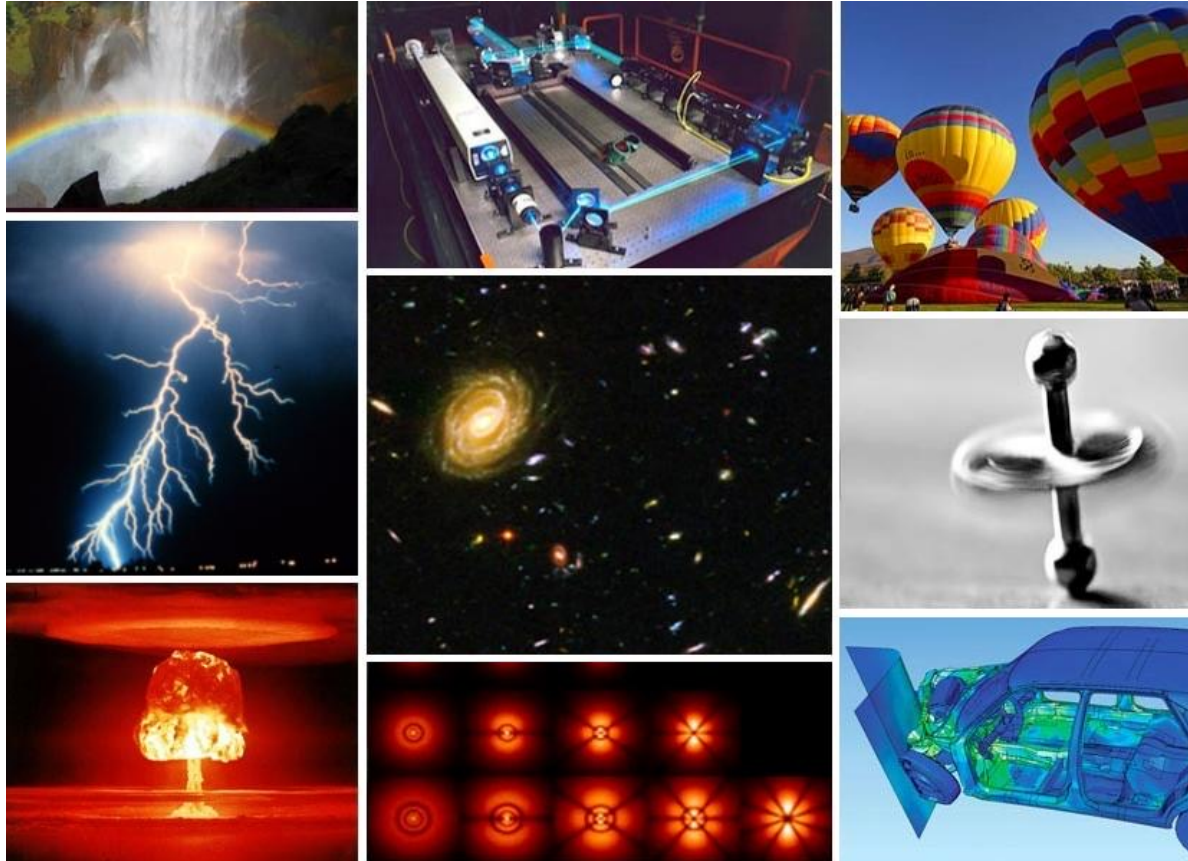
Ist der Mond noch da, wenn niemand hinschaut?

A. Ja

B. Nein

Was ist Physik?

wikipedia.org



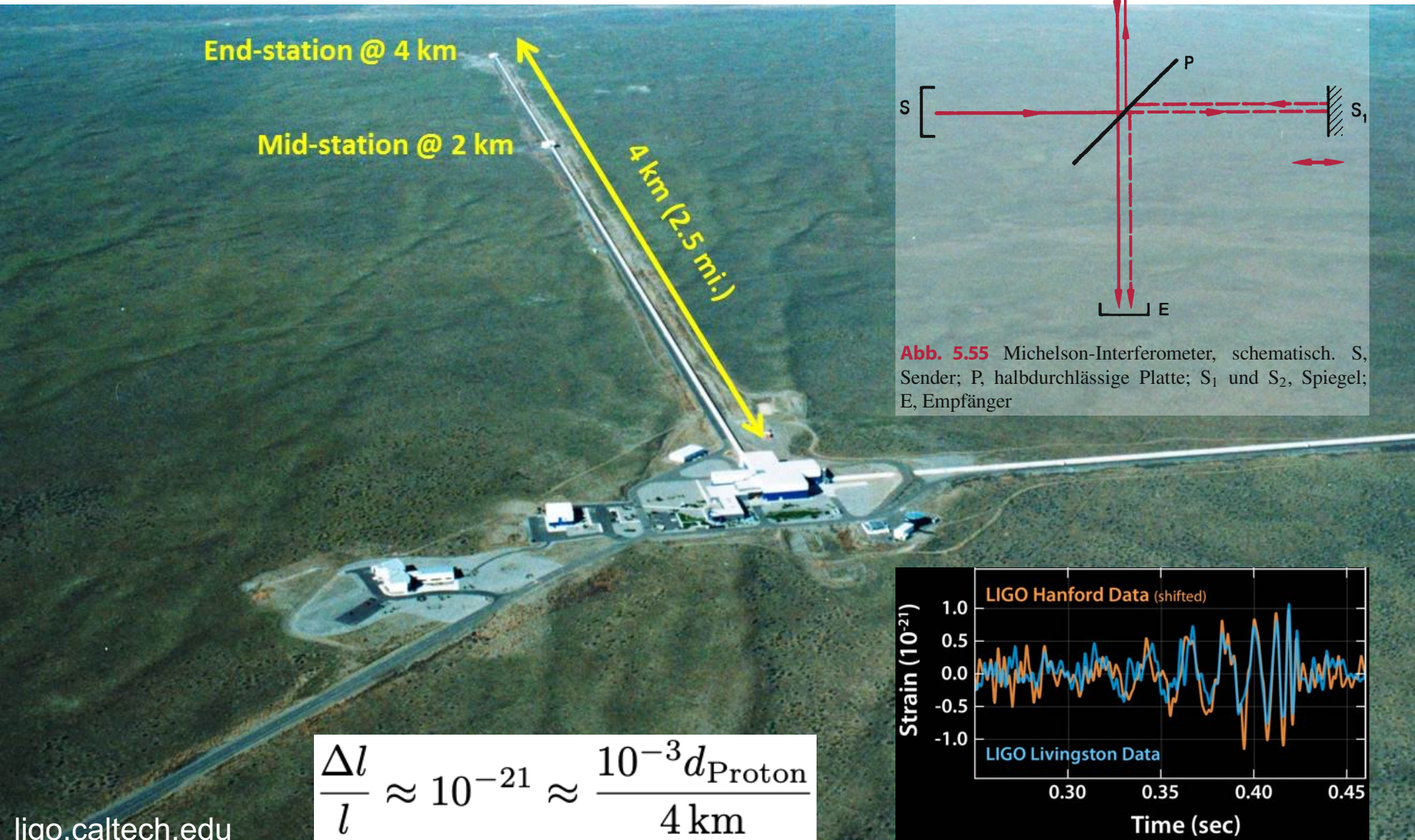
britannica.com

Physics can, at base, be defined as the **science of matter, motion, and energy**. Its laws are typically expressed with economy and precision **in the language of mathematics**.

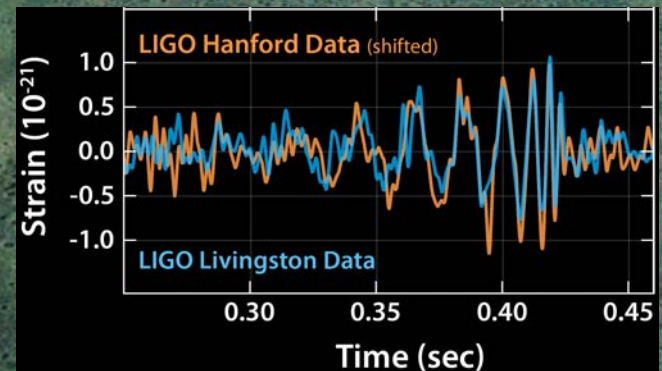
Himmelscheibe von Nebra (ca. 2000 v. Chr.)



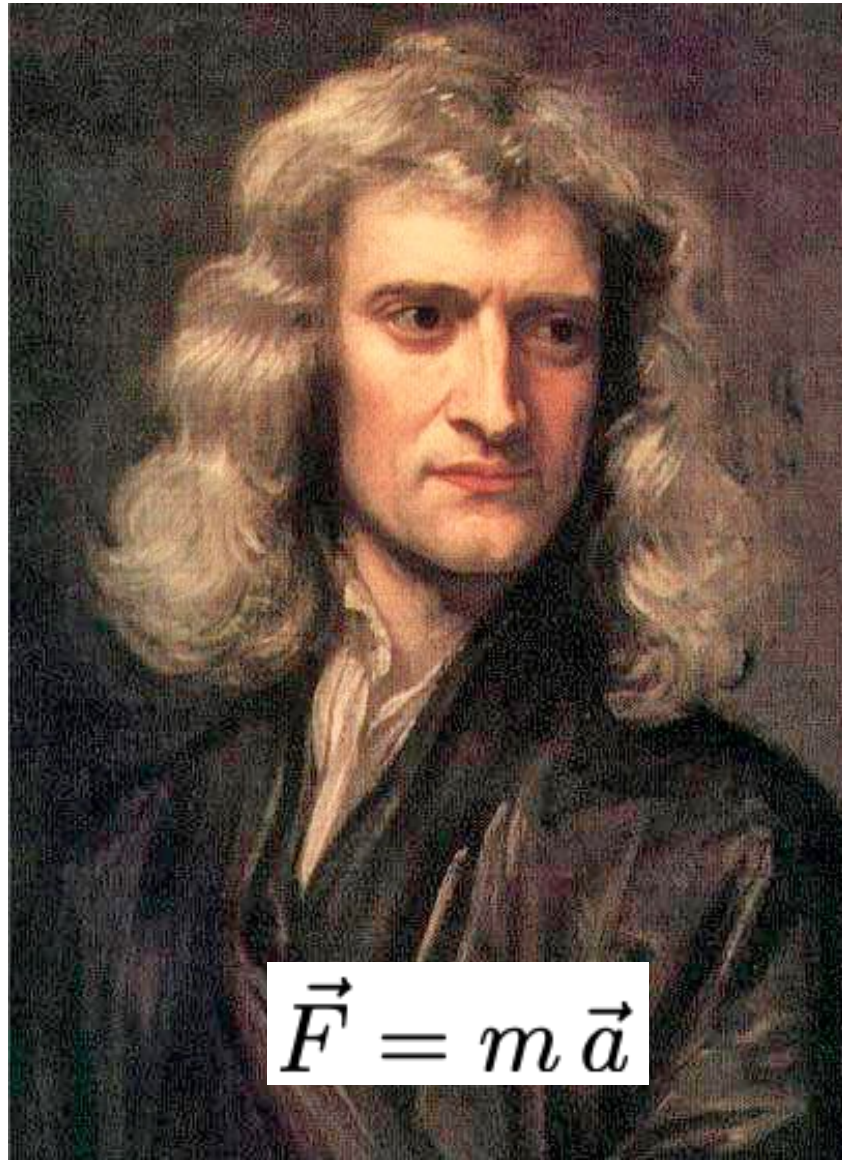
Advanced LIGO (≥ 2015)



$$\frac{\Delta l}{l} \approx 10^{-21} \approx \frac{10^{-3} d_{\text{Proton}}}{4 \text{ km}}$$



Newton's *Principia* (1687)



$$\vec{F} = m \vec{a}$$

PHILOSOPHIÆ
NATURALIS
PRINCIPIA
MATHEMATICA.

Autore J. S. NEWTON, Trin. Coll. Cantab. Soc. Matheseos
Professore Lucasiano, & Societatis Regalis Sodali.

IMPRIMATUR.
S. PEPYS, Reg. Soc. PRÆSES.
Julii 5. 1686.

LONDINI,
Jussu Societatis Regiæ ac Typis Josephi Streater. Prostat apud
plures Bibliopolas. Anno MDCLXXXVII.

Erkenntniswege

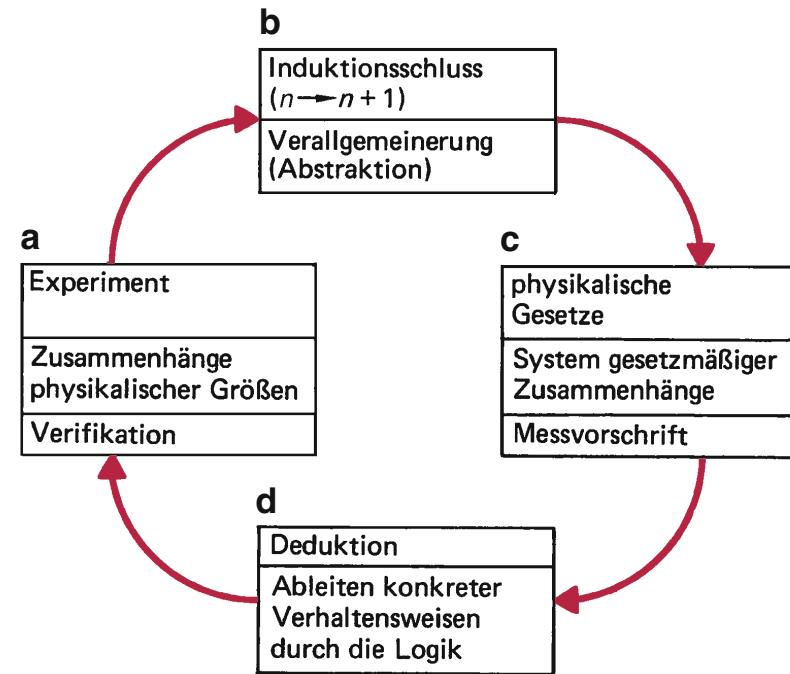
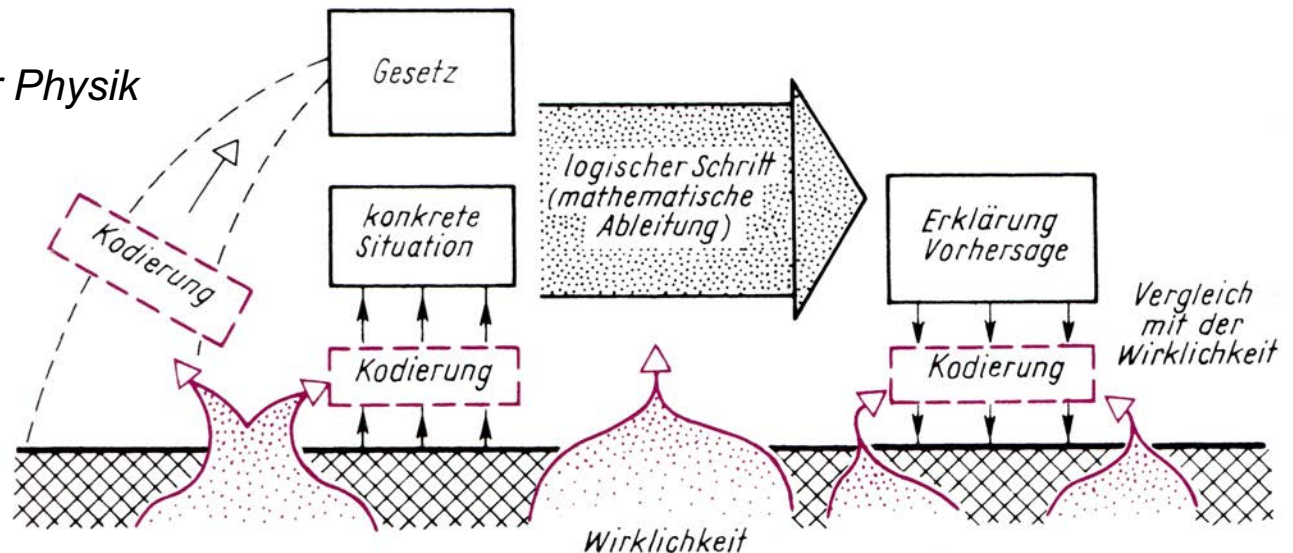


Abb. 1.1 Regelkreis der physikalischen Erkenntnis

K. Simonyi:
Kulturgeschichte der Physik



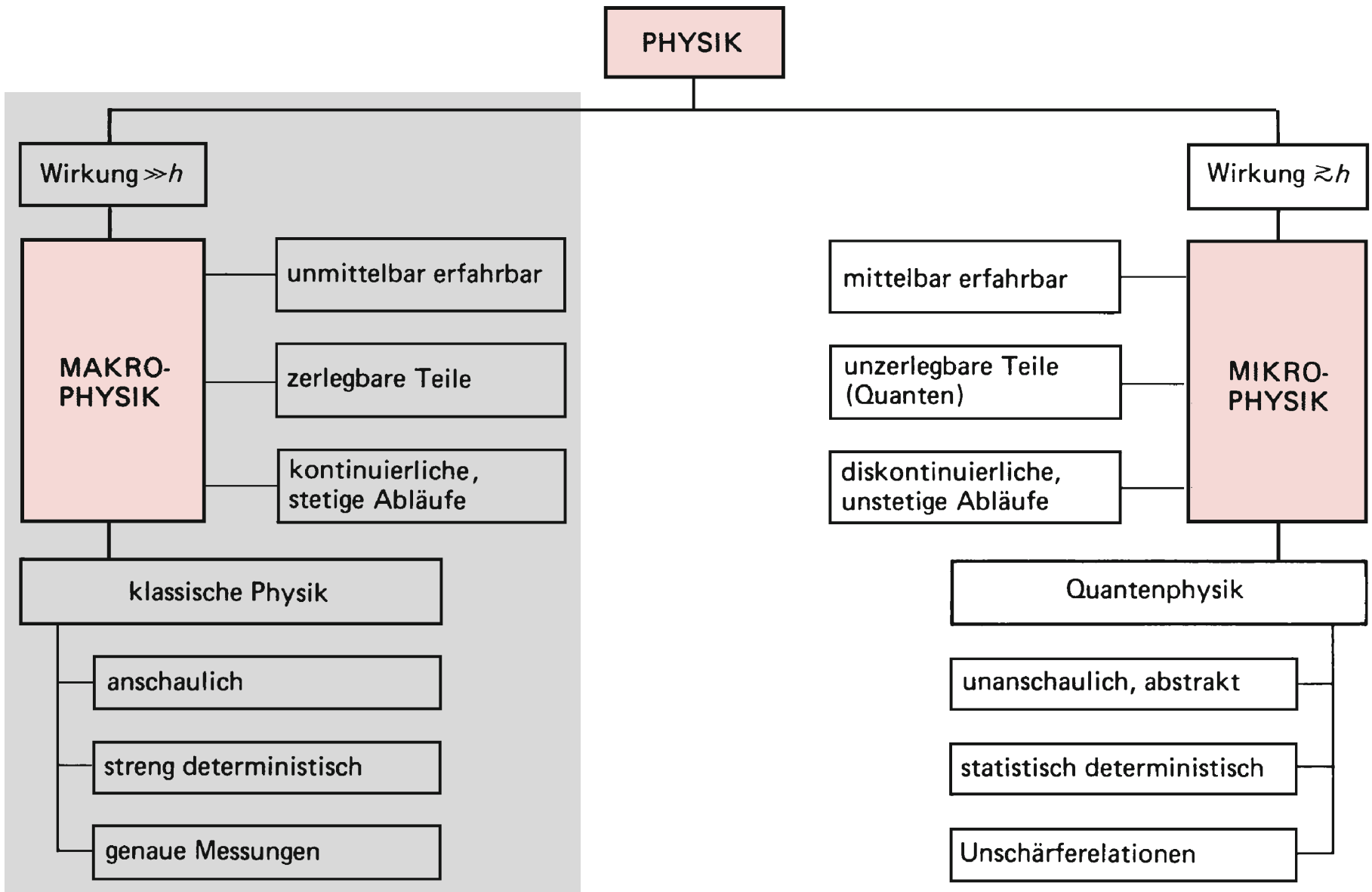


Abb. 1.2 Bereiche der physikalischen Erkenntnis

Quizfrage 3

Wie hängt beim freien Fall die Fallzeit von der Fallhöhe h ab?

A. $\propto h$

B. $\propto \sqrt{h}$

C. $\propto h^2$

D. $\propto 1/h$

Galileis *Discorsi* (1638)



Arbeitsmethode

1. Begriffsdefinition
2. Mathematische Formulierung
3. Hypothese
4. Vorgabe einer Versuchsanordnung
5. Annahme idealisierter Bedingungen
6. Experimentelle Überprüfung

Hammer vs. Feder



youtube.com/watch?v=KDp1tiUsZw8

Zeit-, Längen-, Massenskalen

	Typ. Zeitintervall (s)	Durchmesser (m)	Masse (kg)
Higgs-Boson	10^{-22} (Lebensdauer)	0 (punktförmig)	10^{-25}
H ₂ O-Molekül	10^{-14} (Schwingung)	10^{-10} (O–H)	10^{-26}
Mensch	10^0 (Pulsabstand)	10^0	10^1 – 10^2
Erde	10^5 – 10^7 (Tag–Jahr)	10^7	10^{25}
Universum	10^{17} (Alter)	10^{27}	10^{53} (sichtbar)

Tab.1.1 Bezeichnung der dezimalen Vielfachen und Teile von Einheiten

Zehnerpotenz	Vorsilbe	Kurzzeichen	Beispiel
10^{18}	Exa	E	Em, EJ
10^{15}	Peta	P	Pm, PJ
10^{12}	Tera	T	Tm, TJ
10^9	Giga	G	Gm, GJ
10^6	Mega	M	Mm, MJ
10^3	Kilo	k	km, kJ
10^2	Hekto	h	hPa, hJ
10^1	Deka	da	dam, daJ
10^{-1}	Dezi	d	dm, dJ
10^{-2}	Zenti	c	cm, cJ
10^{-3}	Milli	m	mm, mJ
10^{-6}	Mikro	μ	μm , μJ
10^{-9}	Nano	n	nm, nJ
10^{-12}	Piko	p	pm, pJ
10^{-15}	Femto	f	fm, fJ
10^{-18}	Atto	a	am, aJ

Quizfrage 4

Wenn sich alle Menschen in Deutschland im Corona-Abstand (1.5 m) aufstellen, reicht die Fläche von Fehmarn dafür aus?

A. Ja

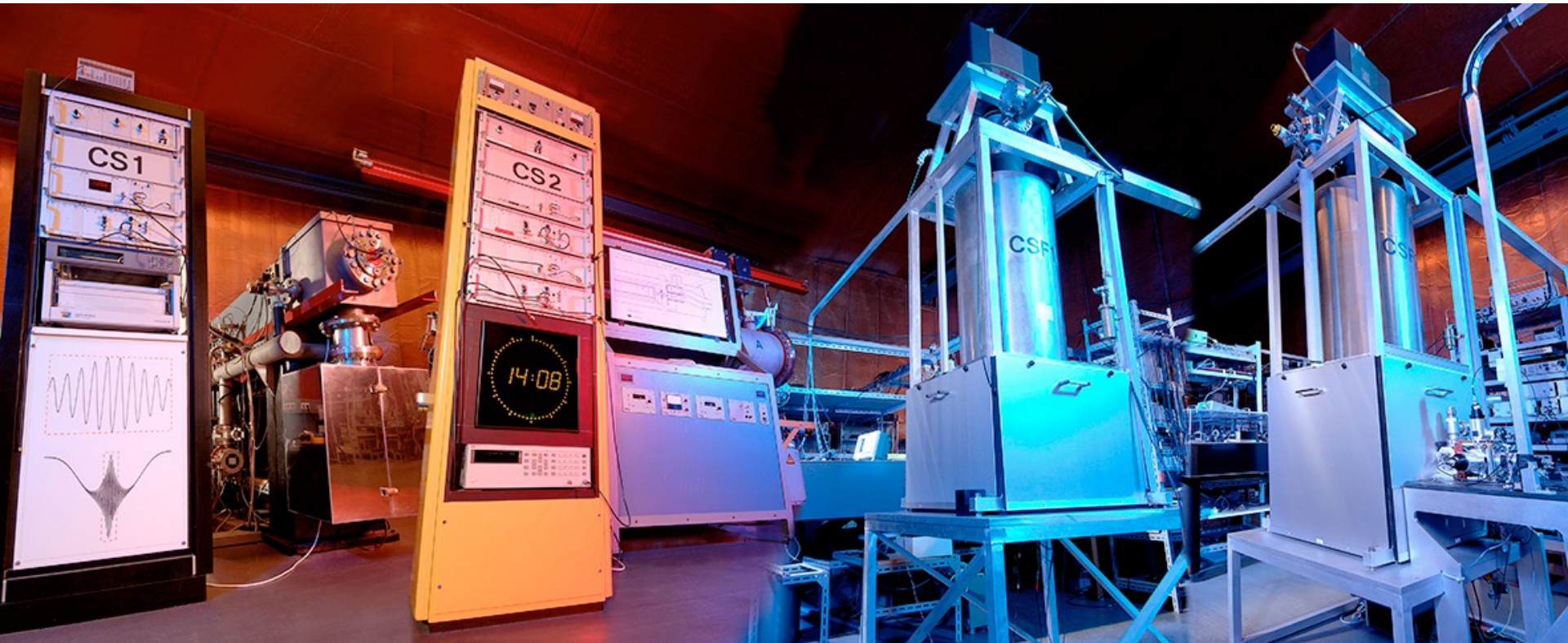
B. Nein

Quizfrage 5

Wieviel Energie steckt in einem aufgeschlagenen Tennisball im Vergleich zu einer fritz-kola ($6 \cdot 10^5$ J)?

- A. Mehr
- B. Ungefähr gleich
- C. Weniger

Atomuhr



ptb.de

$$\Delta\nu(^{133}\text{Cs})_{\text{hfs}} = 9\,192\,631\,770\,\text{s}^{-1}$$

Ur-Kilogramm

Abb. 1 Das „Urkilogramm“ besteht aus einer Platin-Iridium-Legierung (90 % Pt, 10 % Ir) und ist zylinderförmig mit einer Höhe und einem Durchmesser von jeweils 39 mm.



Problem:

$$\Delta m \approx -50 \mu\text{g}/100 \text{ a}$$

Silizium-Kugel

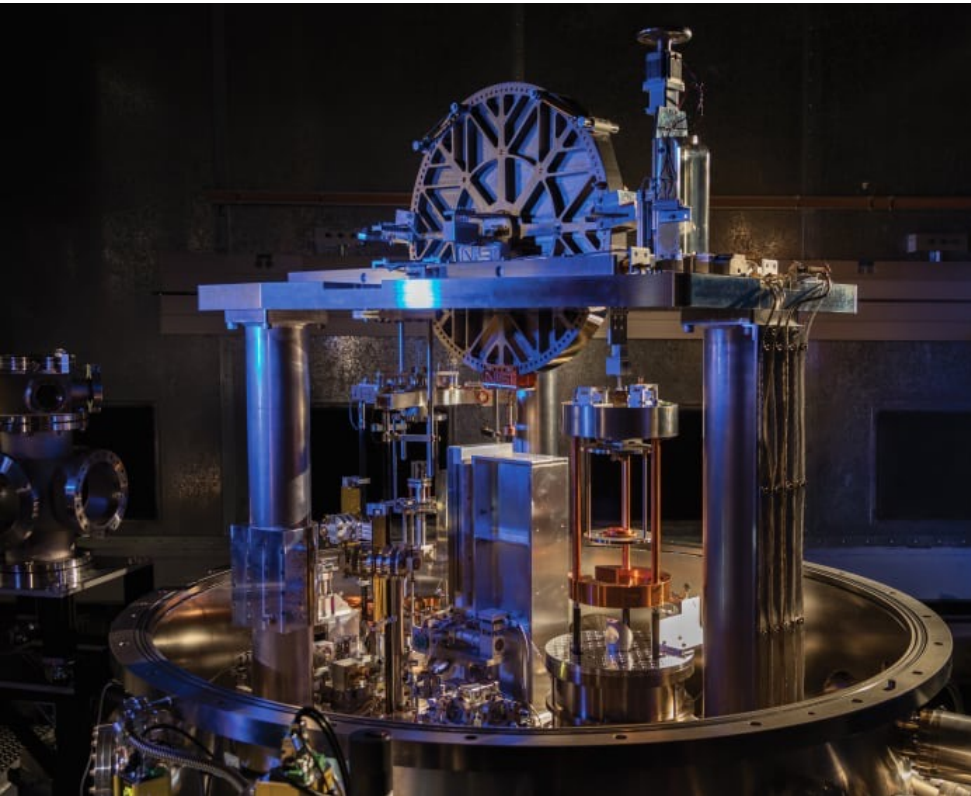


Diese Einkristallkugel aus angereicher-
tem ^{28}Si der internationalen Avogadro-
Kollaboration erlaubt es, einen Zusam-
menhang zwischen einer makrosko-

pischen Masse und der Planck-Konstante
 h herzustellen. Über die Festlegung des
Zahlenwerts von h ist somit eine Neu-
definition des Kilogramms möglich.

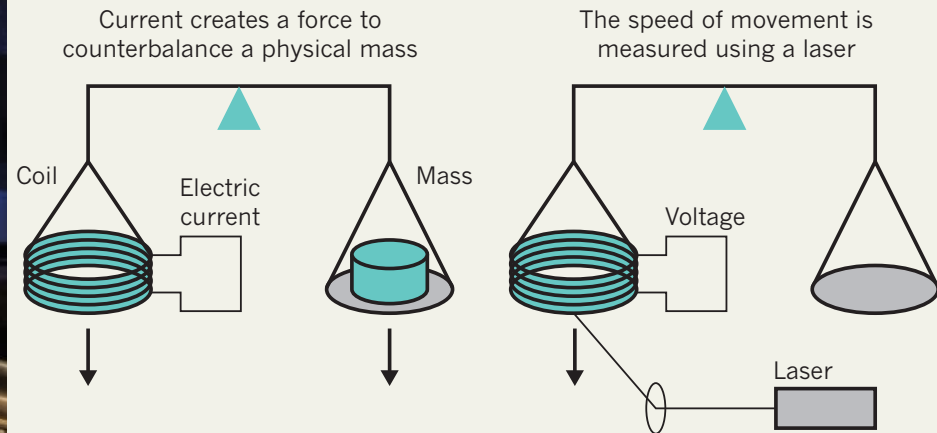
$$\boxed{m_{\text{Kugel}}} = \frac{8V}{a_{220}^3} \cdot \frac{2\boxed{h}R_{\infty}}{c\alpha^2} \cdot \frac{\sum_i f_i A_r^i}{A_e^i} = N_{\text{Atome}} \cdot m_e \cdot \frac{\langle m_{\text{Si}} \rangle}{m_e}$$

Watt-Waage



KILOGRAM: THE WATT BALANCE

The Watt balance compares mechanical power with electromagnetic power using two separate experiments. First, a current is run through a coil in a magnetic field to create a force that counterbalances a known physical mass. Then, the coil is moved through the field to create a voltage. By measuring the speed as well as experimental values that relate the voltage and current to Planck's constant, scientists can precisely determine the weight of a mass in kilograms.



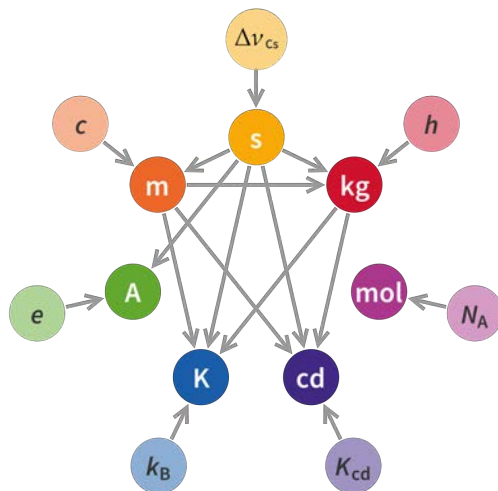
nature.com

$$m \propto h$$

New definitions of scientific units are on the horizon

Metrologists are poised to change how scientists measure the Universe.

Einheiten-Definition über festgelegte Naturkonstanten



wikipedia.org



bipm.org/en/
measurement-units/
base-units.html

ALL CHANGE

Under the revised SI system, every unit will be defined in relation to a constant, whose value will become fixed. Many of the units will be defined in relation to each other: for example, definition of the kilogram requires Planck's constant, and definitions of the second and metre.*

→ Dependency

SECOND (s)

Measures: Time
Requires: Hyperfine-transition frequency of the caesium-133 atom
Definition: Duration of 9,192,631,770 cycles of the radiation corresponding to the transition between two hyperfine levels of caesium-133

METRE (m)

Measures: Length
Requires: Speed of light
Definition: Length of the path travelled by light in a vacuum in $1/299,792,458$ seconds

AMPERE (A)

Measures: Current
Requires: Charge on the electron
Definition: Electric current corresponding to the flow of $1/(1.602\,176\,620\,8 \times 10^{-19})$ elementary charges per second

KELVIN (K)

Measures: Temperature
Requires: Boltzmann's constant
Definition: equal to a change in thermal energy of $1.380\,648\,52 \times 10^{-23}$ joules

KILOGRAM (kg)

Measures: Mass
Requires: Planck's constant
Definition: One kilogram is Planck's constant divided by $6.626\,070\,040 \times 10^{-34} \text{ ms}^{-2}$

MOLE (mol)

Measures: Amount of substance
Requires: Avogadro's constant
Definition: Amount of substance of a system that contains $6.022\,140\,857 \times 10^{23}$ specified elementary entities

CANDELA (cd)

Measures: Luminous intensity
Requires: Luminous efficacy of monochromatic light of frequency $540 \times 10^{12} \text{ Hz}$
Definition: Luminous intensity of a light source with frequency $540 \times 10^{12} \text{ Hz}$ and a radiant intensity of $1/683$ watts per steradian

*Final values for the constants will be published later this month. Definitions do not represent the exact text of the new SI.

Quizfrage 6

Hat ein mol Katzen eine größere Masse als der Mond ($7 \cdot 10^{22}$ kg)?

A. Ja

B. Nein