známe co měříme a vlastně

Víme co je teplota ?

Jaroslav Šesták

New Technology - Research Center in the Westbohemian Region, West Bohemian University, Universitni 8, CZ-30114 Plzeň;

E-mail: sestak@fzu.cz

NOVÉ TECHNOLOGIE
VÝZKUMNÉ CENTRUM
ZÁPADOČESKÉ
UNIVERZITY
V PLZNI

Kalsem 2018

Kutná hora

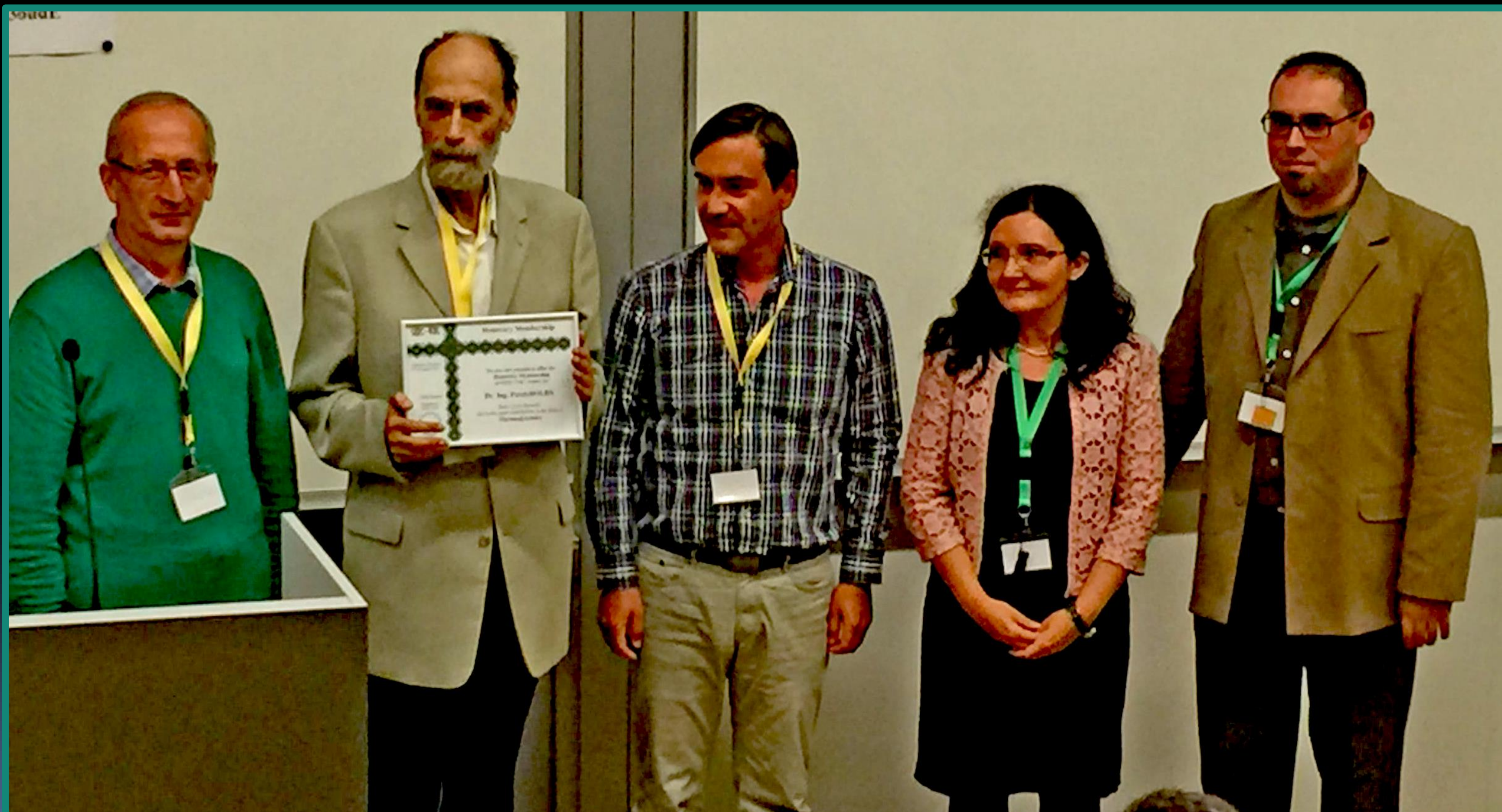
Санкт Петербург, Сентябр 2013
St Petersburg , September 2013

with
⇐ Igor Archangelski
and Jurij Metlin ⇓

NTC - With Broněk Foller

Holba last conference
CEEC Ljublajana 2015

Pavel Holba received thermodynamic award at CEEC-TACV conference, Ljubljana, August 2015



Udělení nejvyšší ruské medaile Kurnakova za termodynamiku.

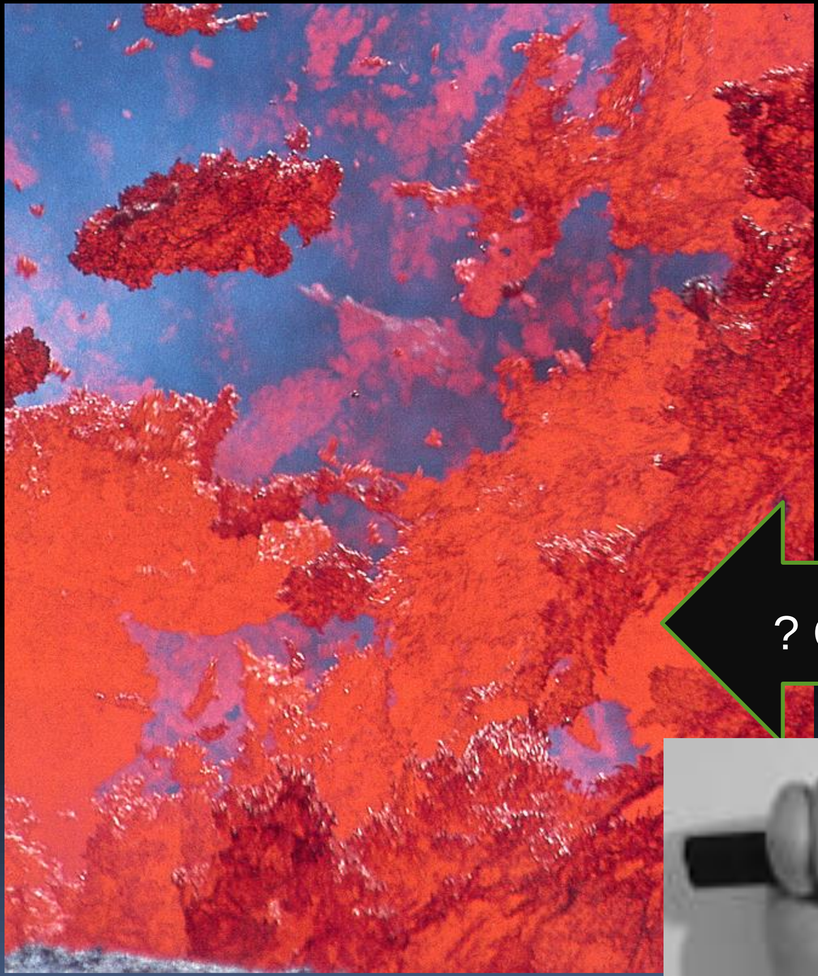
In memoriam RCTAC konference, St Pterburg, září 2016

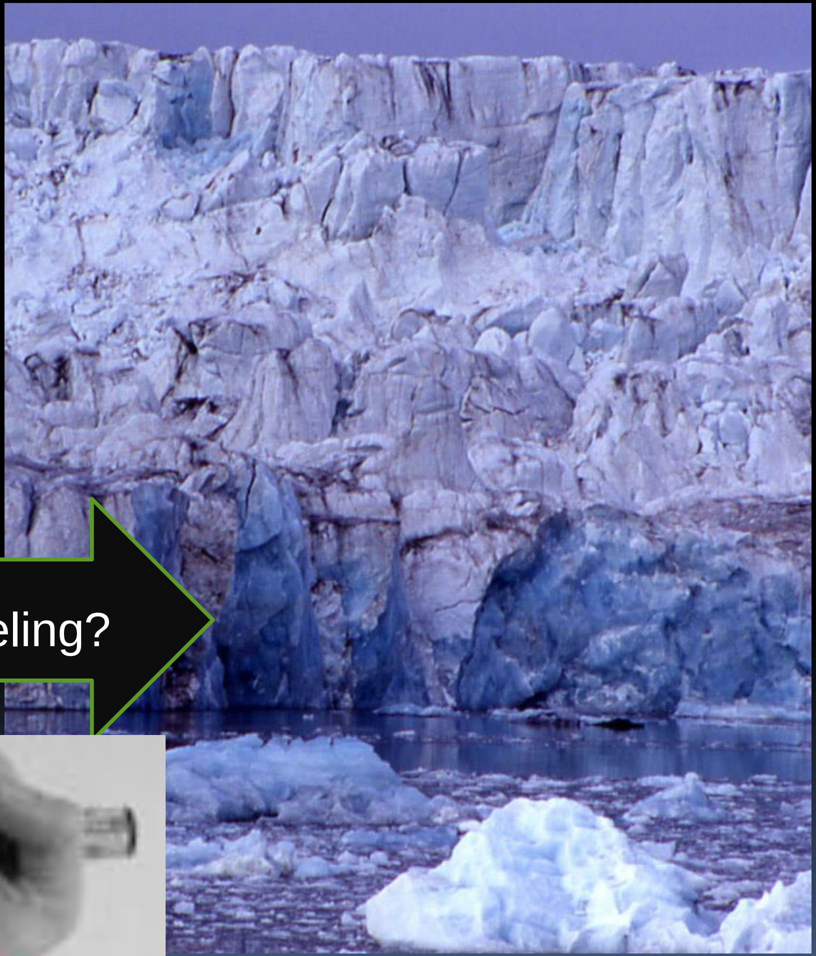
Курнаков Н. С. 1860-1941 - Соединенiе и химическiй индивидъ

1918-34 - основатель и первый директор Института физико-
химического анализа АН СССР
1925 – первое издание книги Введение в физико-химический анализ
(2.;в 1928 г.;, 3. в 1935 г.,, 4. в 1940 г..- Izd AN   SSSR M.-L. 562 стр.)
1937-41 - заведующий кафедрой неорганической химии МГУ

Teplota vs. naše cítění ?

heat = fire **cold = ice**





? Our feeling?

Wood-worm

Holding a bar of …

Metal- cold

Co měříme? Jak to měříme ? Kde to měříme ?

Vždycky něco naměříme !!

Velká vzdálenost

Velká rychlost

Logika versus fzzika/matematika

Co když ale budeme pozorovat chování teploty z jedoucího vlaku

Makroskopický extrém

Relativistická transformace

$T = T_0\sqrt{(1 - v^2/c^2)}$ K. v. Mosengeil (1907)

$T = T_0/\sqrt{(1 - v^2/c^2)}$ H. Ott (1963)

$T = T_0$ P. T. Landsberg (1966)

⇒ Dlouhodobá kontraverze – problém relativistické fyziky

⇒ Naše řešení

⇒ $k = k_0\sqrt{(1 - v^2/c^2)}$, $R = R_0\sqrt{(1 - v^2/c^2)}$

J.J. Mareš, J. Šesták, V. Špička, P. Hubík, J. Krištofik, *Temperature Transformation and Mosengeil-Ott's Antinomy.* Physica E 42 (2010) 484

TEPLO, TEPLOTA, TEPLOZPYT

Temperature	Heat
Temperatur	Wärme
Température	chaleur
Teplota	**teplo**
Temperatura	ciepło
Температура	тепло
Θερμοκρασία	Θερμότητα

Kabaret Majora Kopřivy: **Mrazospytem k teplozpytu**

Teplo – teplozpyt ⇔ calorimetry

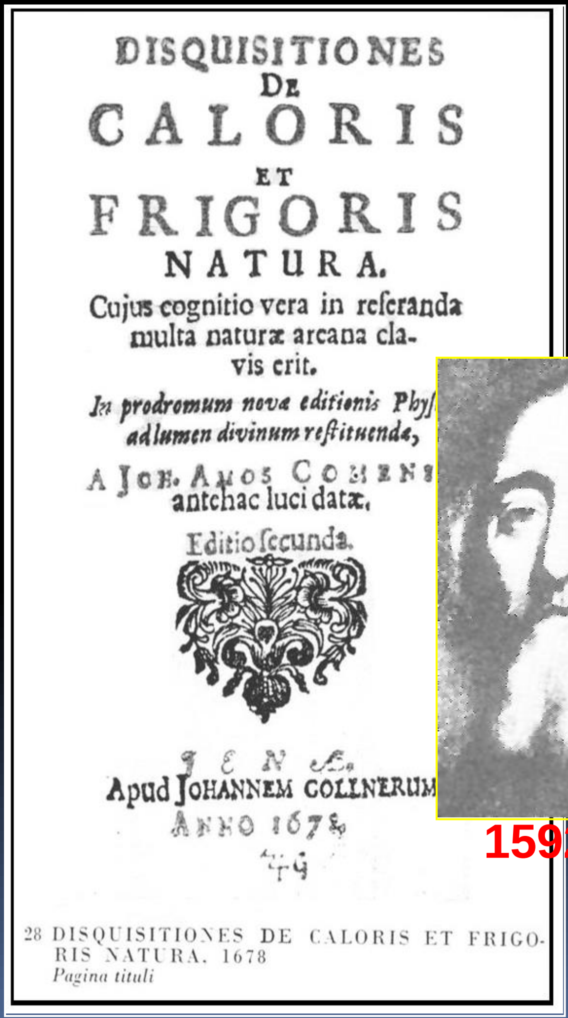
J.A. Komenský

Heat: calor, fervor a ardor

tempor

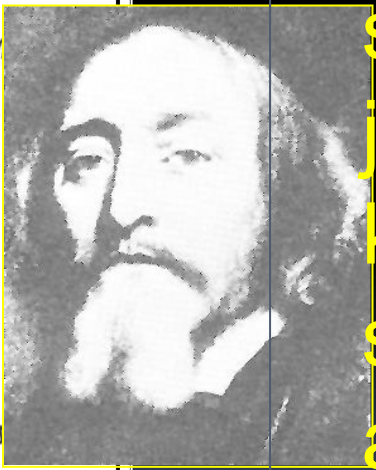
Cold: frigus, algor and ??

Not yet distinguishing temperature



DISQUISITIONES
DE
CALORIS
ET
FRIGORIS
NATURA.
Cujus cognitio vera in reſeranda multa naturæ arcana clavis erit.
In prodromum novæ editionis Phyſ… ad lumen divinum reſtituendæ,
A JOH. AMOS COMEN… antehac luci datæ,
Editio ſecunda.
JENÆ,
Apud JOHANNEM COLLNERUM
ANNO 1678.

28 DISQUISITIONES DE CALORIS ET FRIGORIS NATURA, 1678
Pagina tituli



1592-1670

„ „Abychom účinky tepla a zimy spatřili světle, sluší se vzíti předmět viditelný i sluší se pošetřovati změn jeho, když se ohřeje i když se zase ochladí, aby se očitě ukázalo, co teplo a zima dělají smyslům pochopitelné“

“ introduced „ caloric“

Reneissance :

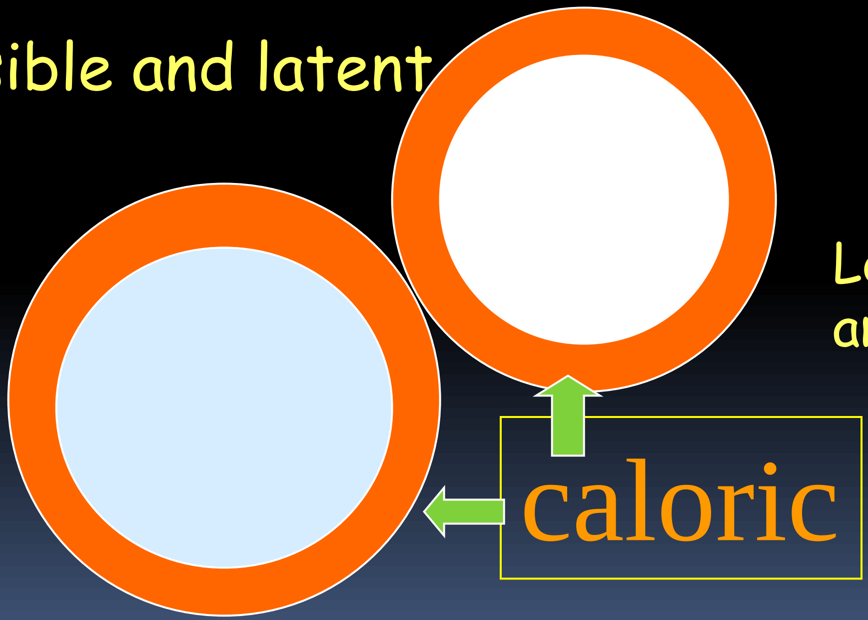
phlogiston-fuel- palivina

caloricum-medium-teplík

- Becher, Stahl → phlogistom (terra pinquis)

Metal = CALX + phlogiston

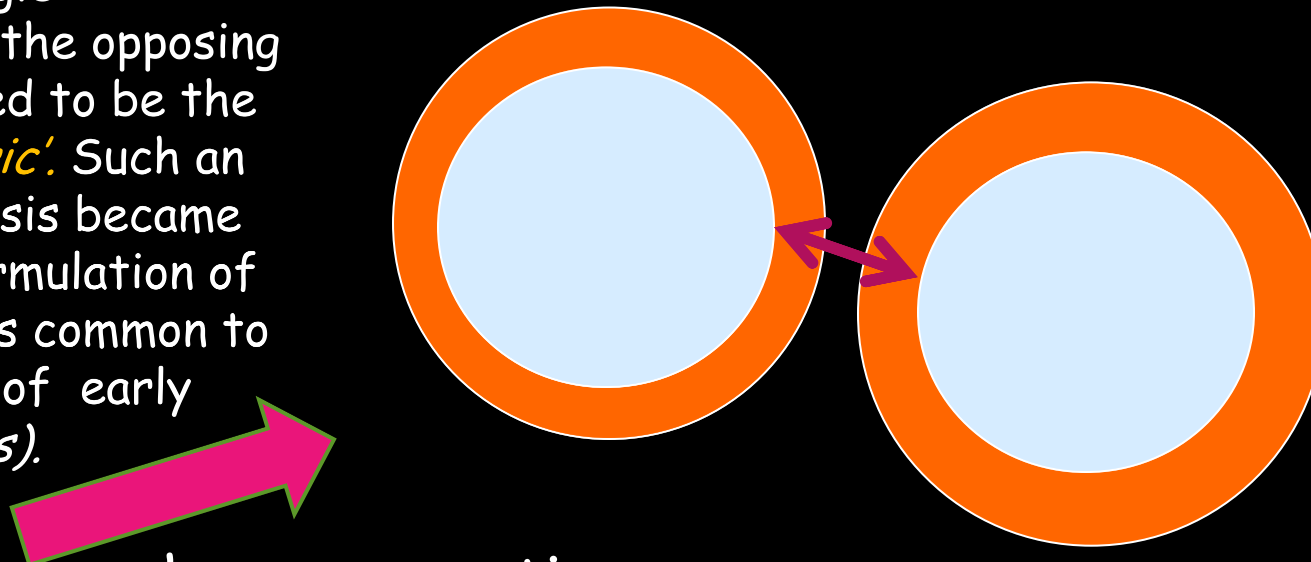
Sensible and latent heat



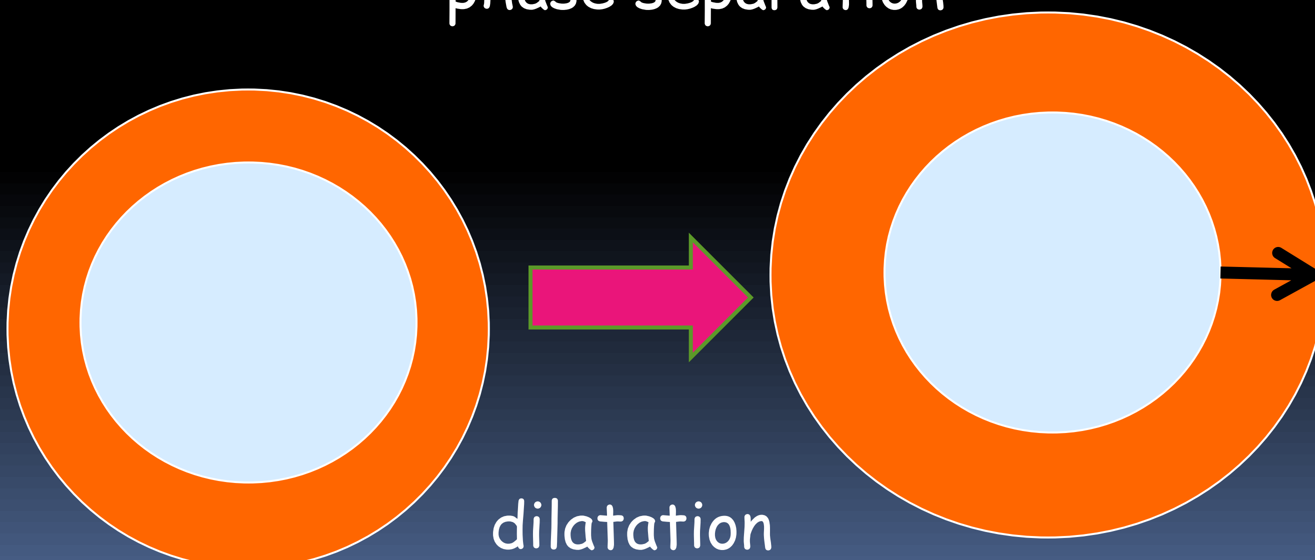
Logarithmic dependence between amount (quantity) and intensity

←**Black,Irving, Sheele Pristley, Cavendish**

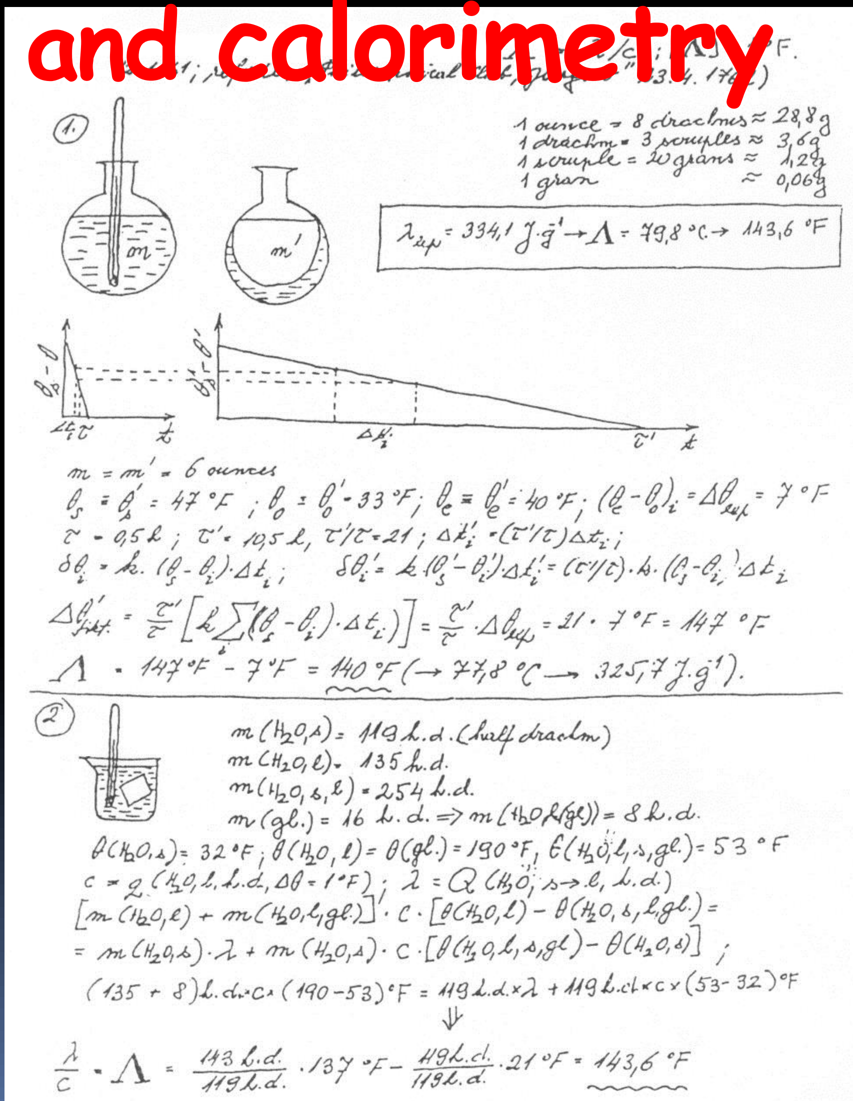
In order to stay away from a total gravitational collision, which would produce a single homogeneous mass, the opposing force was considered to be the '*self-repulsive caloric*'. Such an early 'fluid' hypothesis became important in the formulation of modern laws and was common to the way of thinking of early Greeks (*Archimedes*).

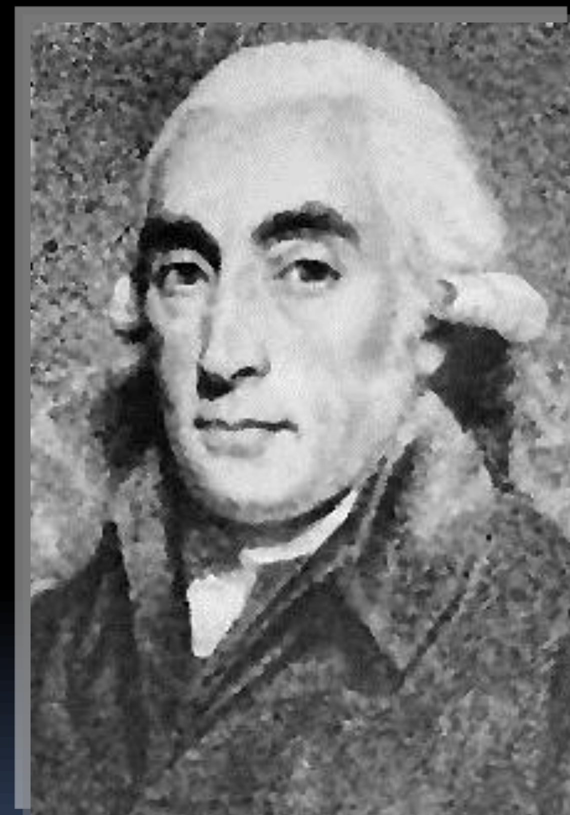


phase separation



Distinguishing specific heat, latent heat and temperature: launching thermometry and calorimetry

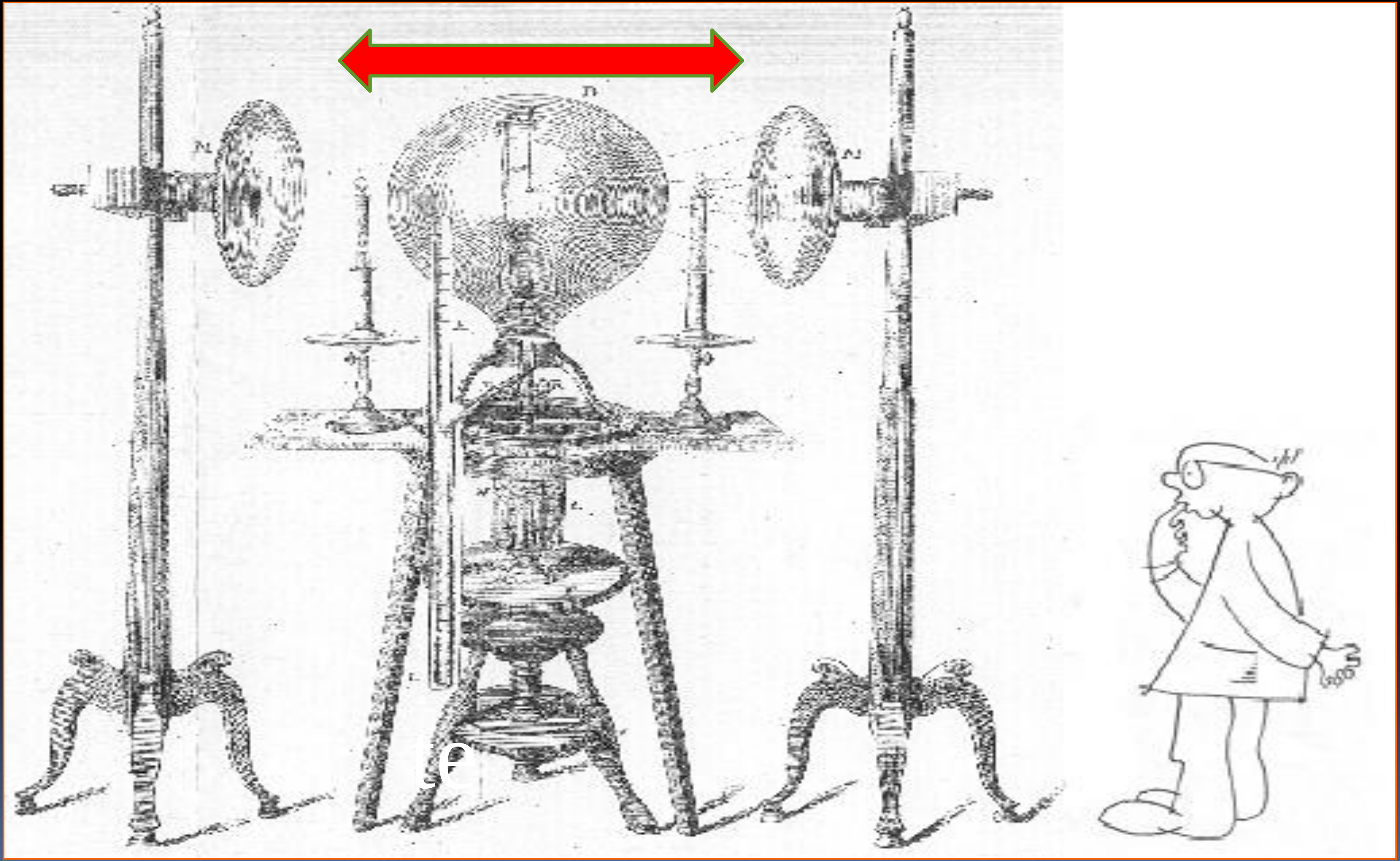




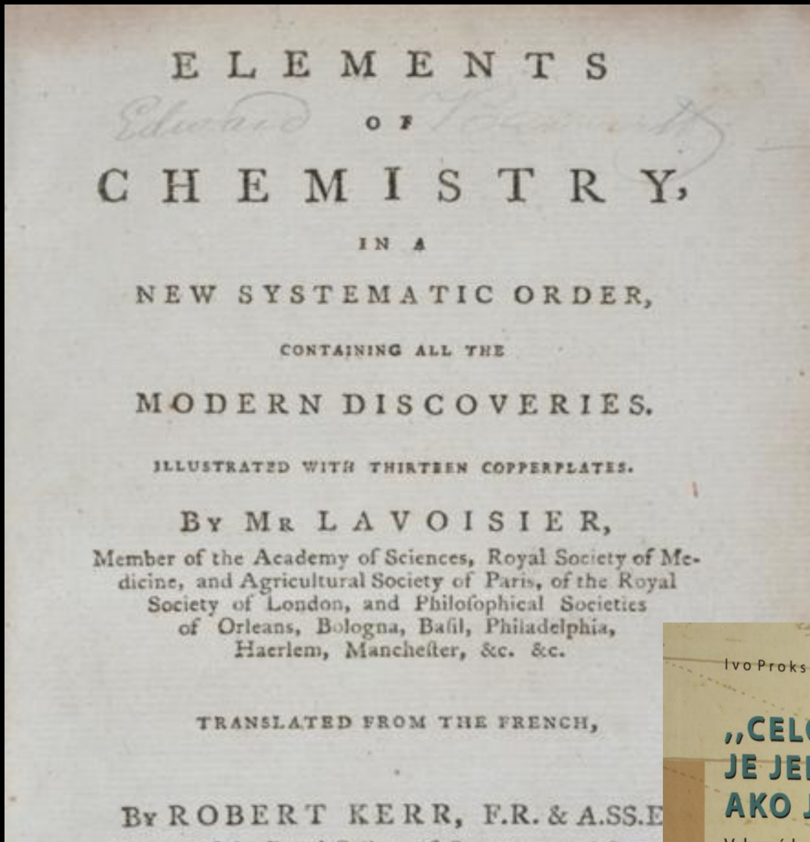
J. Black (1728-1799)
J. Irvine (1733-1791)

Poincaré 1790

Particles of **HEAT and COLD**



Heat as an element


ELEMENTS

OF

CHEMISTRY,

IN A

NEW SYSTEMATIC ORDER,

CONTAINING ALL THE

MODERN DISCOVERIES.

ILLUSTRATED WITH THIRTEEN COPPERPLATES.

By MR LAVOISIER,

Member of the Academy of Sciences, Royal Society of Medicine, and Agricultural Society of Paris, of the Royal Society of London, and Philoſophical Societies of Orleans, Bologna, Baſil, Philadelphia, Haerlem, Mancheſter, &c. &c.

TRANSLATED FROM THE FRENCH,

By ROBERT KERR, F.R. & A.SS.E

... of the Royal College of Surgeons, and Surge...
... an Hoſpital of Edinburgh.

...NBURGH:
...LLIAM CREECH, AND SOLD
... G. G. AND J. J. ROBINSONS.

MDCCXC.

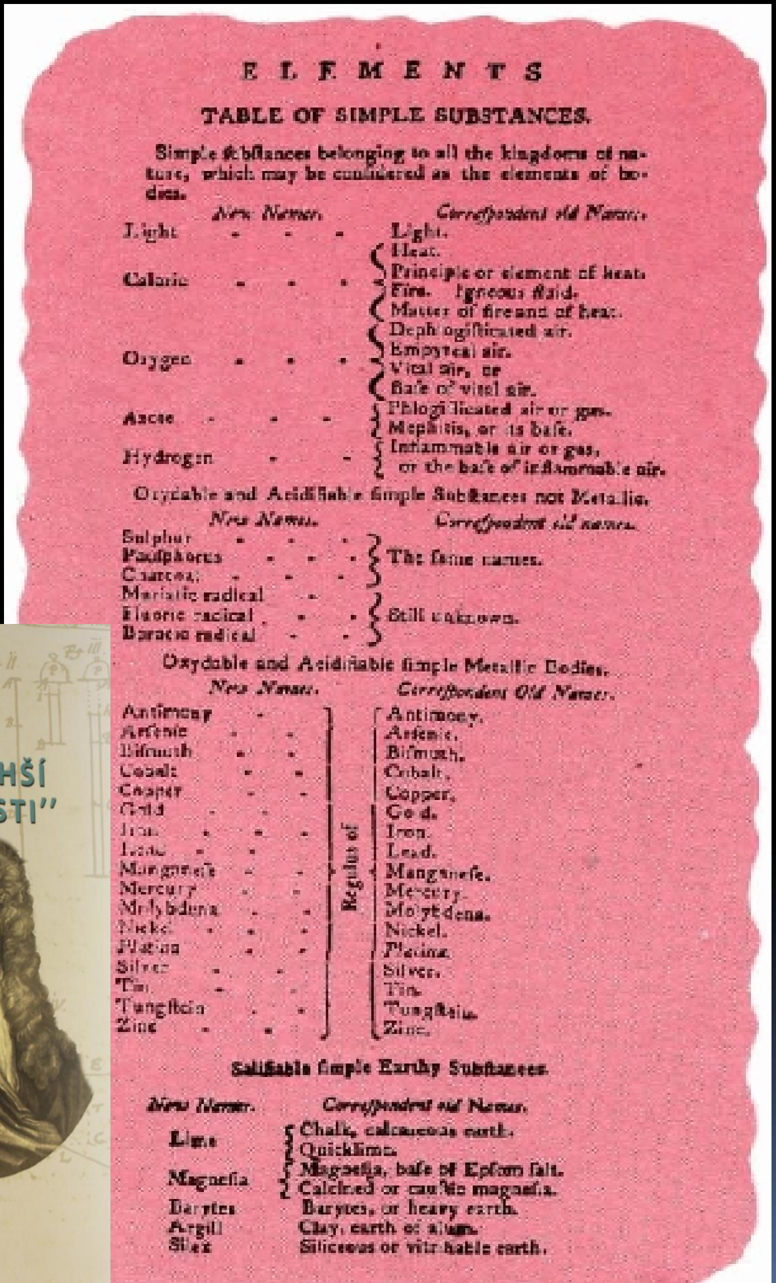

ELEMENTS

TABLE OF SIMPLE SUBSTANCES.

Simple ſubſtances belonging to all the kingdoms of nature, which may be conſidered as the elements of bodies.

New Names.	Correſpondent old Names.
Light	Light.
Caloric	Heat. Principle or element of heat. Fire. Igneous fluid. Matter of fire and of heat.
Oxygen	Dephlogiſticated air. Empyreal air. Vital air, or Baſe of vital air.
Azote	Phlogiſticated air or gas. Mephitis, or its baſe.
Hydrogen	Inflammable air or gas, or the baſe of inflammable air.

Oxydable and Acidifiable ſimple Subſtances not Metallic.

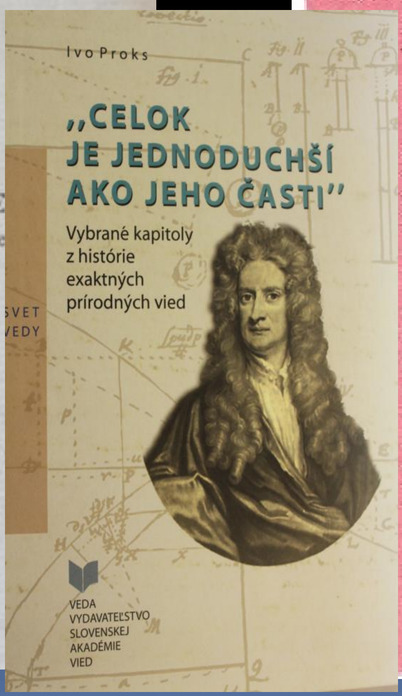
New Names.	Correſpondent old names.
Sulphur	The ſame names.
Phoſphorus	The ſame names.
Charcoal	The ſame names.
Muriatic radical	Still unknown.
Fluoric radical	Still unknown.
Boracic radical	Still unknown.

Oxydable and Acidifiable ſimple Metallic Bodies.

New Names.	Correſpondent Old Names.
Antimony	Regulus of Antimony.
Arſenic	Regulus of Arſenic.
Biſmuth	Regulus of Biſmuth.
Cobalt	Regulus of Cobalt.
Copper	Regulus of Copper.
Gold	Regulus of Gold.
Iron	Regulus of Iron.
Lead	Regulus of Lead.
Mangaueſe	Regulus of Mangaueſe.
Mercury	Regulus of Mercury.
Molybdena	Regulus of Molybdena.
Nickel	Regulus of Nickel.
Platina	Regulus of Platina.
Silver	Regulus of Silver.
Tin	Regulus of Tin.
Tungſtein	Regulus of Tungſtein.
Zinc	Regulus of Zinc.

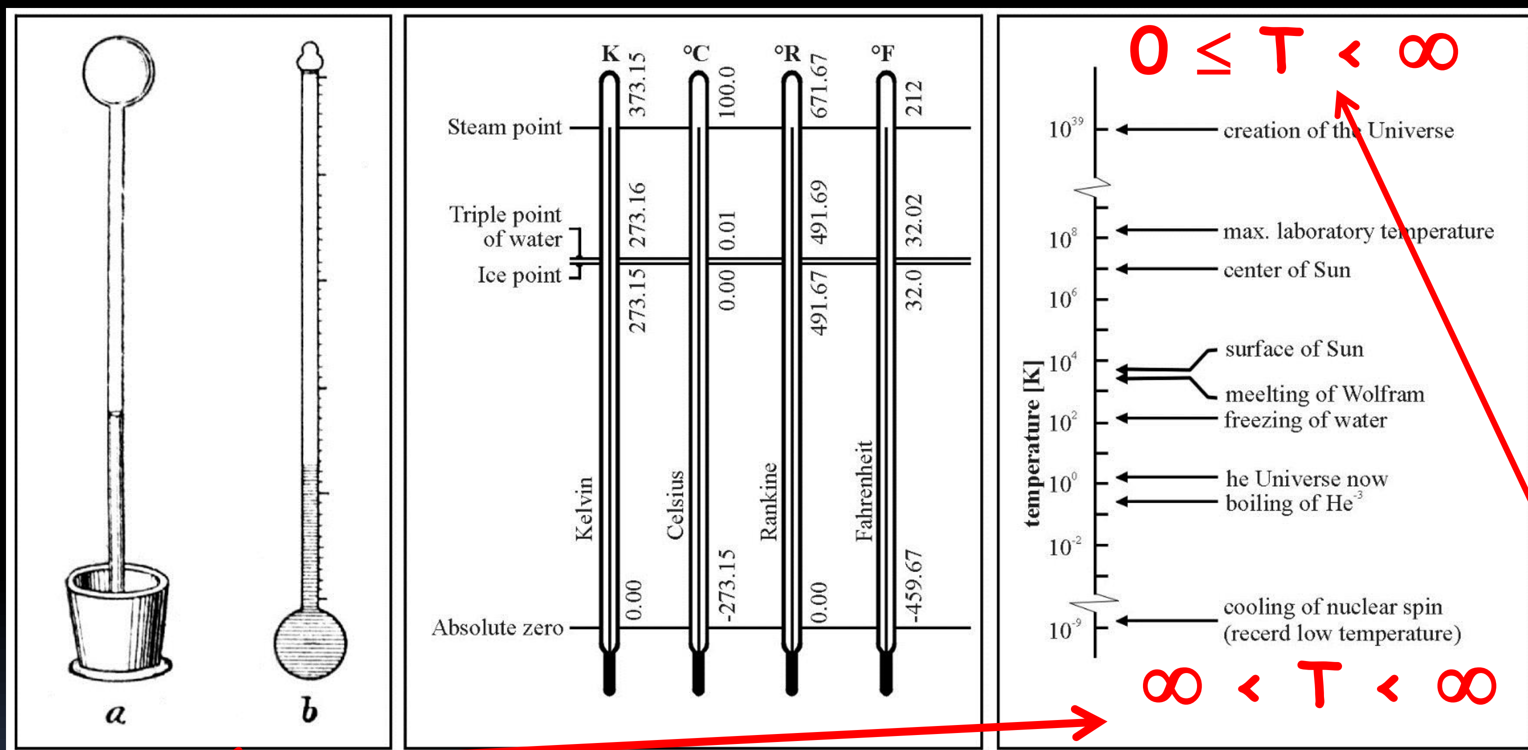
Salifiable ſimple Earthy Subſtances.

New Names.	Correſpondent old Names.
Lime	Chalk, calcareous earth. Quicklime.
Magneſia	Magneſia, baſe of Epſom ſalt. Calcined or cauſtic magneſia.
Barytes	Barytes, or heavy earth.
Argill	Clay, earth of alum.
Silex	Siliceous or vitrifiable earth.



Temperature scale & calibration

Čím horší pivo, tím dříve zmrzne



Newton ($T=12\{2^{x-1}\}$, 0-34), Amontons ($V\rightarrow 0$, $T\rightarrow 0$)

⇒Kelvin, Römer, Fahrenheit, 32-212), Celsius (100-0

⇒Linné 0-100), Thomson ($Th = c1 \ln T + c2$, $To \rightarrow \infty$)

Jan Amos Comenius: **What is what in TA ?**

"to observe clearly the effect of heat and cold, a visible object should be subjected to heating and subsequent cooling, the sensible changes made by heat and cold will then be visible to the eye" Seventeen Century

Thermal analysis is a branch of materials science where the properties of materials are studied as they change with temperature. Several methods are commonly used – these are distinguished from one another by the property which is measured

Wikipedia definition

macro ??

Temperature T

(heat q)

Thermal analysis

T vs T or T vs time

Universe, Earth climate, weather

	Universe	10^{6} light years	
	planet	km	
⇐	man	m	(sec)
	molecule	nm	
	electron	10^{-16} m	

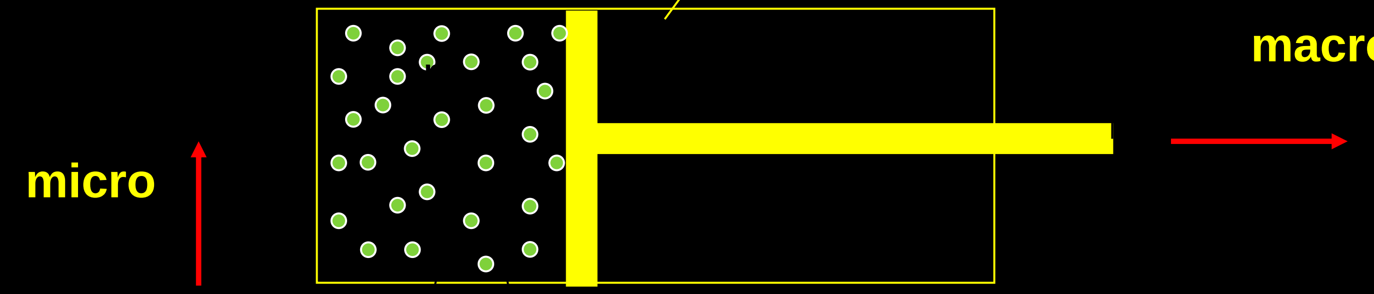
Chemical and quantum processes

micro ??

Thermodynamic laws

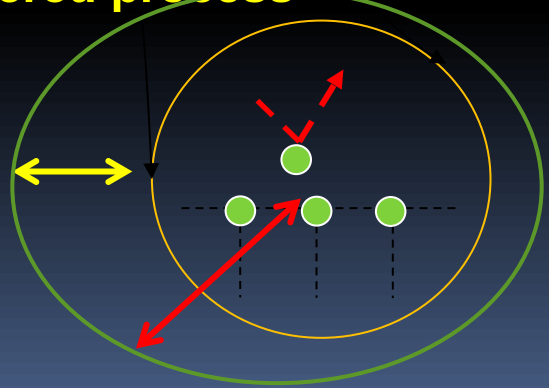
difference between „Order“ and „Chaos“

Temperature and heat/entropy

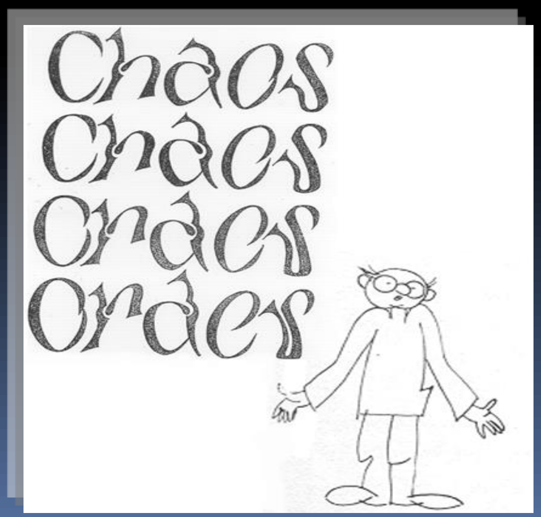


we cannot use energy arbitralrily becaouse of entropical limits

$\Delta U/\Delta V = P \Rightarrow$ **ordered process**



$\Delta U/\Delta S = T \Rightarrow$ chaotic process



Similarity of Newton's law of gravitation

$$F = m\,a$$

ensue many other principles

Law of heat transfer (Fourier) $q = \lambda \nabla T$

Law of diffusion (Fick) $J = D\,\nabla c$

Law of electric flaw (Ohm) $I = r\,\nabla u$

Law of thermal inertia $Y_i = C_p d^2T/dT^2$

Fluid-like flow of 'caloricum'

As well as surface tension, mobility in liquids,
(such as further Stokes', Newton's law) etc

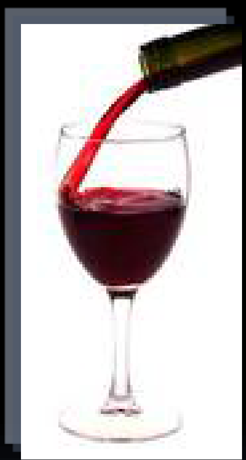
?What is caloricum

In modern theories?

Fluid-like transfer

Pouruing liquid and filling a bottle is not instantaneous but needs certain time

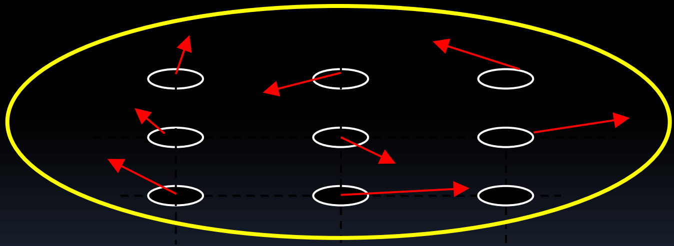
Inserting "heat" to the vibration and ordering modes is not immediate but needs explicit time



m

C_p

similarity



Any matter transport desires definite time lag

Heat sink within the sample thermal capacity

Gravity on a micro-level

Newton gave to us the deterministic description of our physical world whilst always aware that it could be a part of a superior universe (extending from the very small to the extremely large). He intuitively associated heat conduction with temperature gradients called '*gradus caloricum*' (whereupon gradient is derived from Greek '*gradus*' which means felicitous, congenial). *Newton* even tried to make some quantitative observations by heating one end of a metallic bar and observing heat propagation by detecting the progress of melting of various substances (wax) at different distances. It helped him to formulate the law of cooling without knowing what heat actually was. Let's remind het flow *q* is dependent on temperatures T_h and T_c and heat capacities *C* :

$$q = K(T_h - T_c) = C_h\,(dT_h/dt) + C_c\,(dT_c/dt)$$

assuming $C_{c,}$ C_h and T_c = const, we obtain

$$K(T_h - T_c) = -\,C_h\,(dT_h/dt) \Rightarrow K(T_h - T_c)\,dt + C_h\,dT_h = 0$$

$$(K / C_h)\, dT = d\, \mathit{ln}\, K(T_h - T_c)$$

⇓

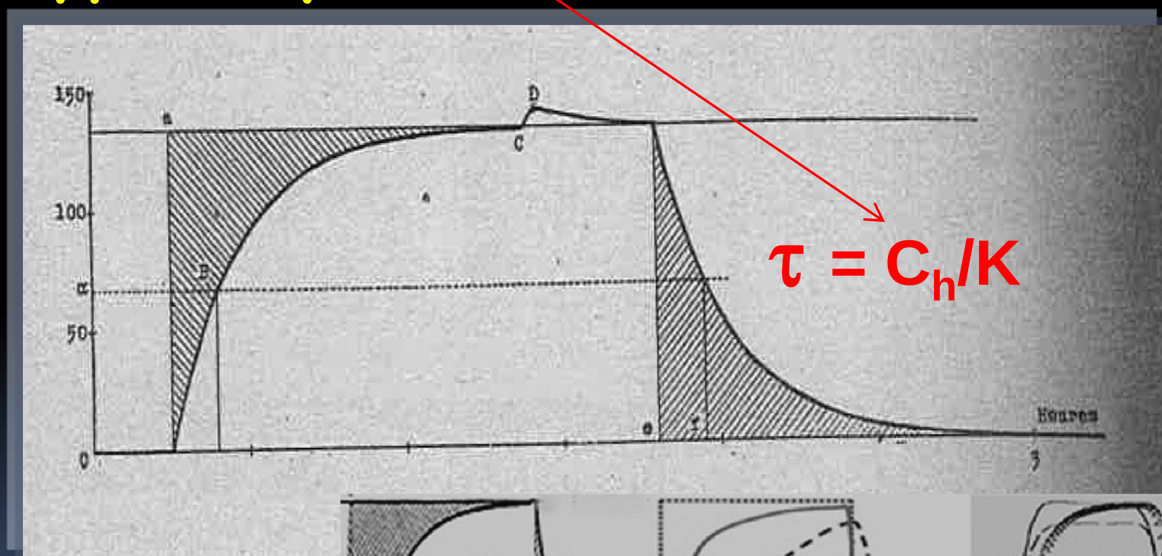
$$(T_h - T_c) = (T_{ho} - T_c)\ \mathit{exp}\ (- (t - to)/\tau)$$

where T_{ho} is the *initial temperature* of hot body and

$\tau = C_h/K$ is called ***time constant of cooling***.

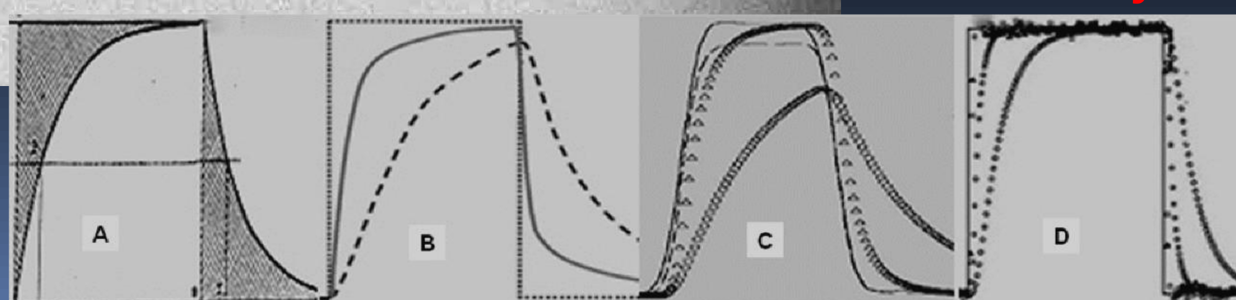
Latter applied by Tian in his basic calorimetric equation

History 1933 ⇒



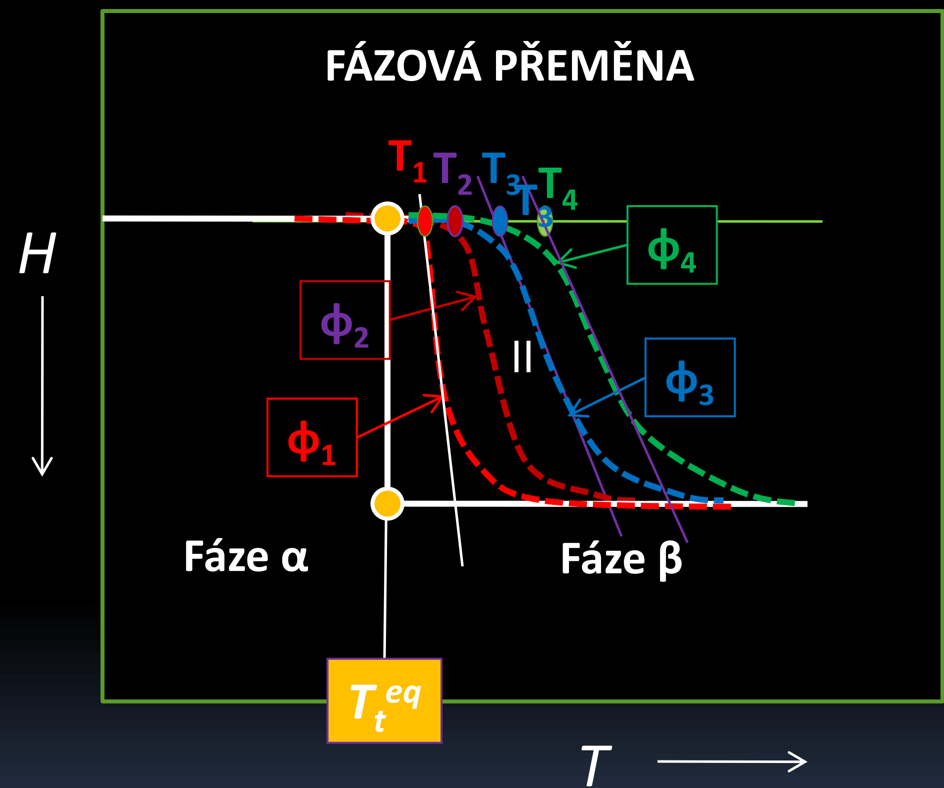
$\tau = C_h/K$

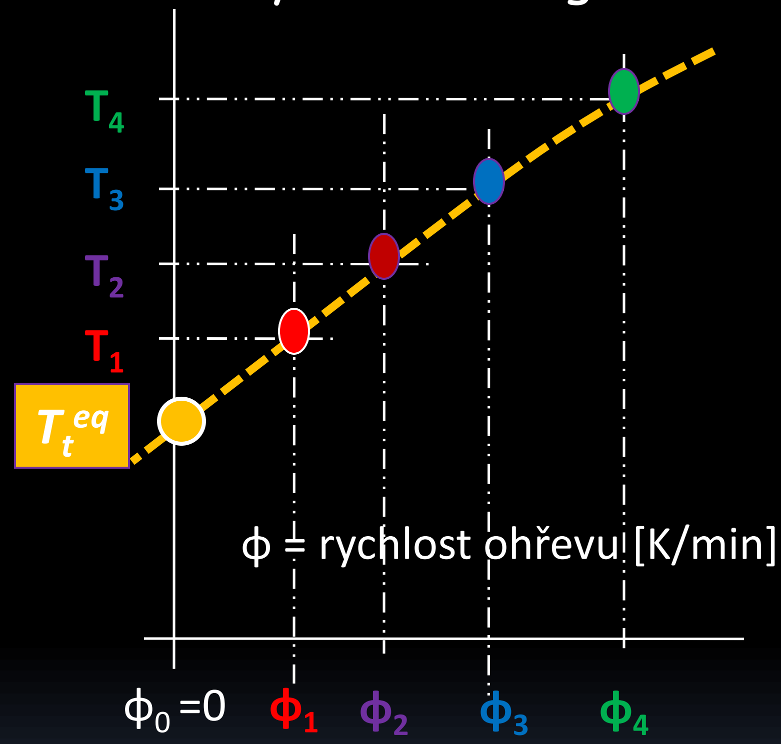
Present day ⇓



Rovnovážná teplota fázové přeměny: T_t^{eq}

Holba´s life attempt to give kinetics its thermodynamic backgroundnd

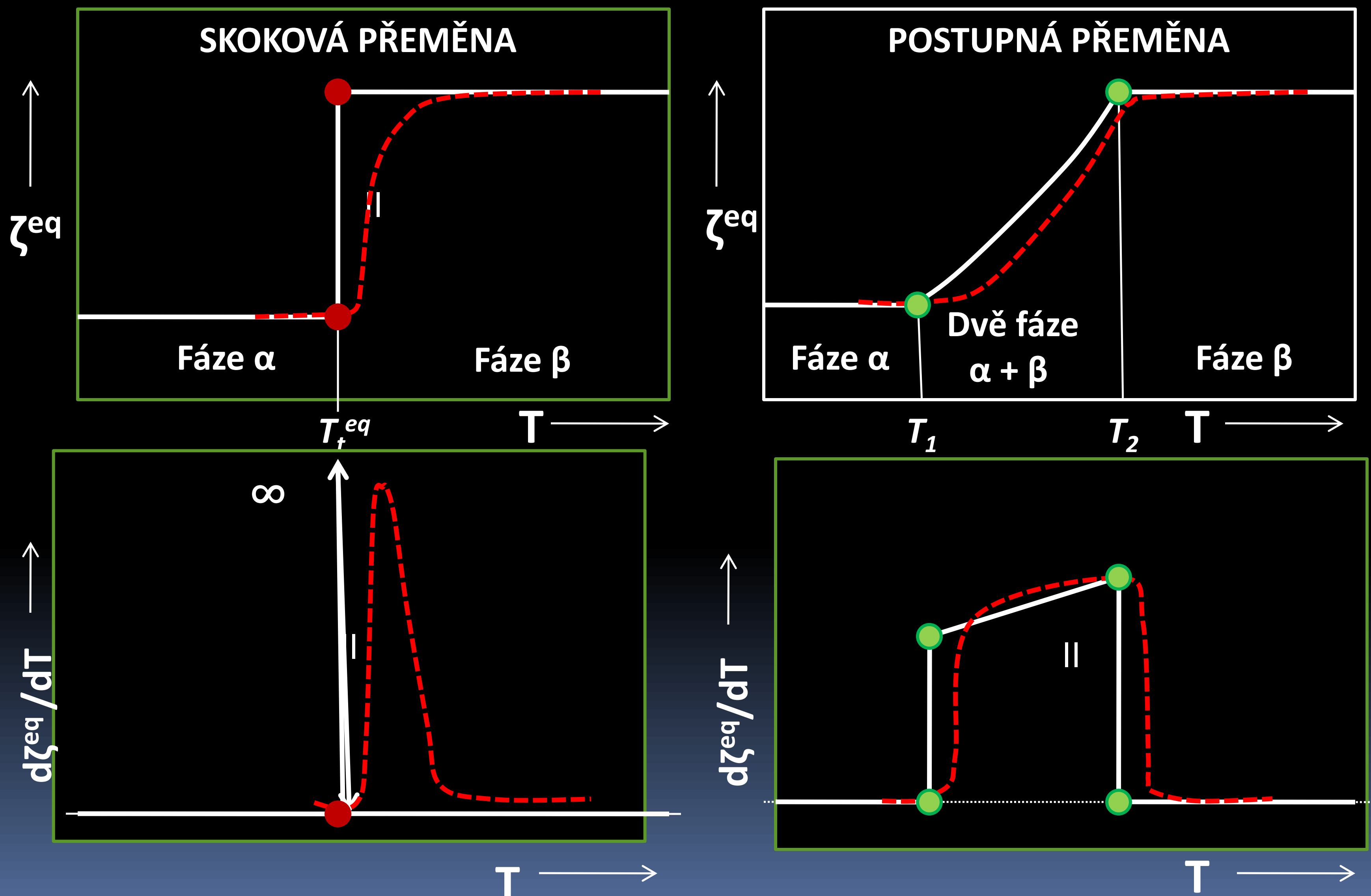




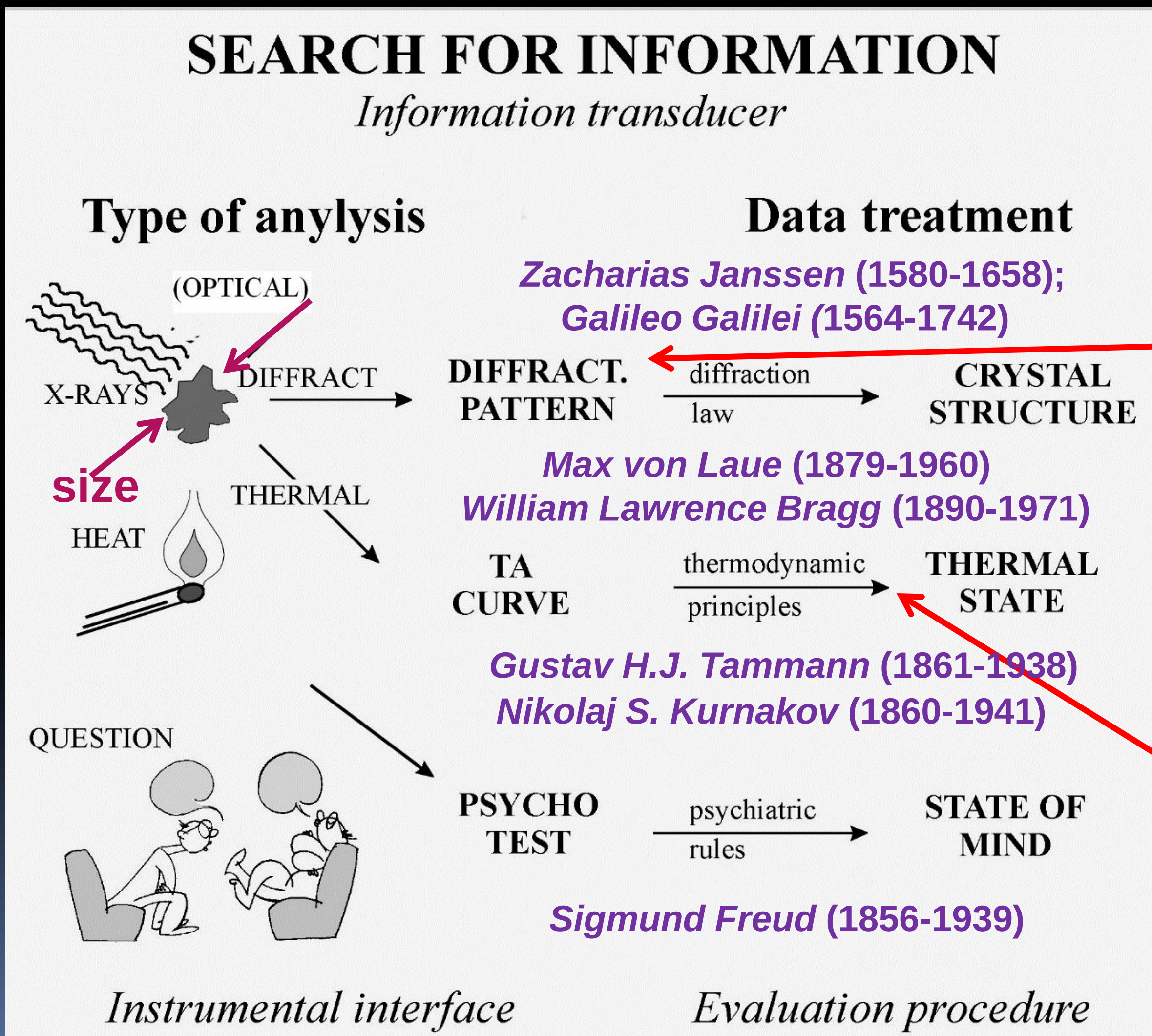
Holba P., Šesták J. (1972) Kinetics with regard to the equilibrium of processes studied by non-Isothermal techniques, Zeit. physik. Chem. N.F. 80: 1; and Holba P (2015) Ehrenfest equations for calorimetry and dilatometry. J Therm Anal Calorim. 120, 175-181.

Fázové přeměny a teplotní derivace

entalpie



ANALYSIS analogy



optical ~ 600 nm
(set-up of crystals)

Nondestructive

X-ray ~ 0.5 nm
(ordering of atoms)

Destructive

Spectroscopic methods

Heat transfer methods

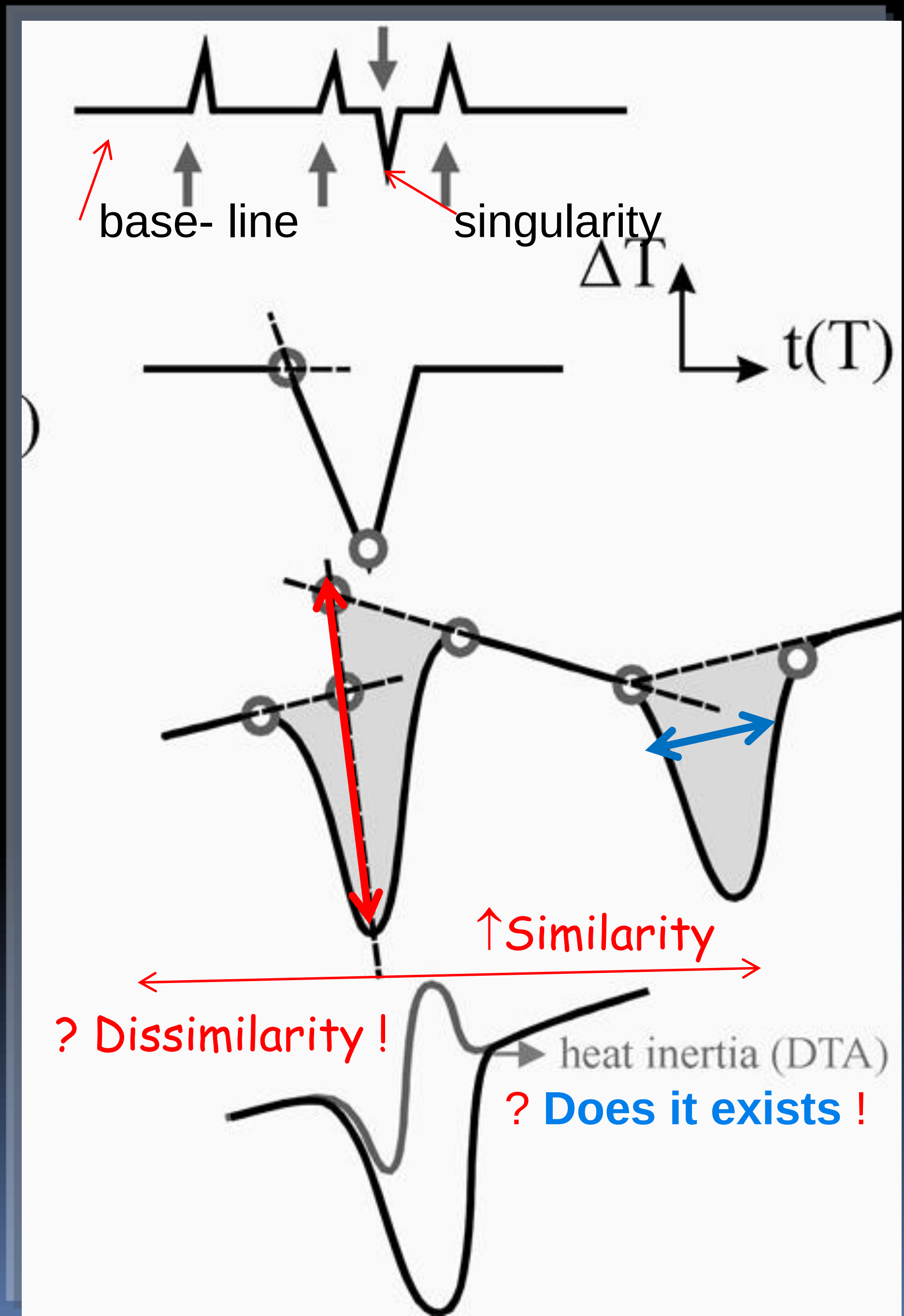
X-ray

Identity
“fingerprint“

Position
Symmetry
Quality

Quantity
Intensity
Area

Shape
Broadening
Crystal size



DTA

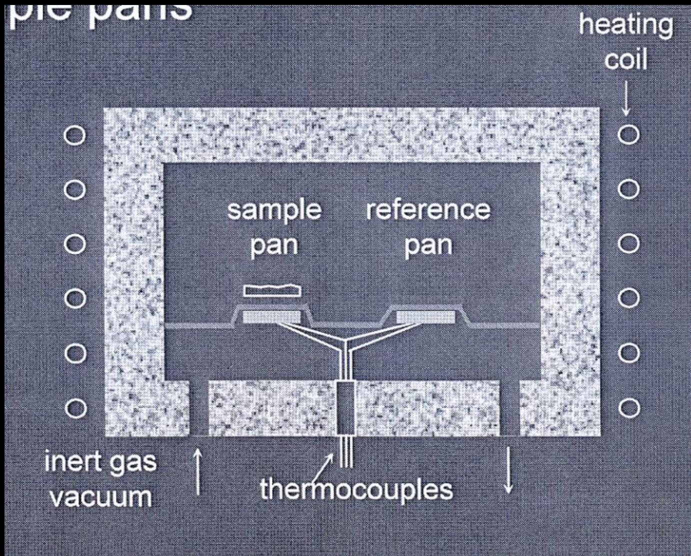
Identity
“fingerprint“

Position
Uniformity
Quality

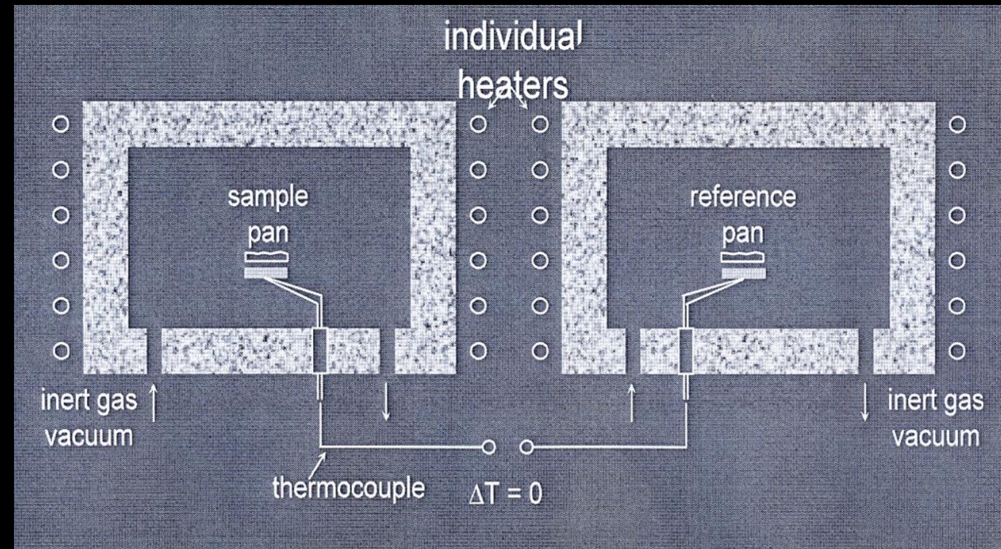
Quantity
Size
Area

Shape
Structure
Kinetics

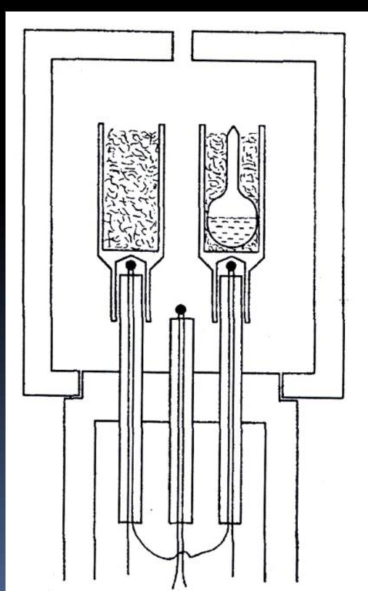
Heat-flux DSC

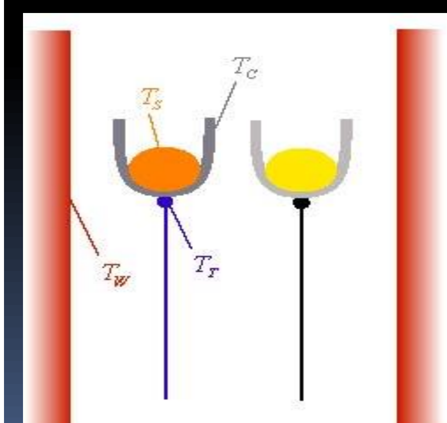


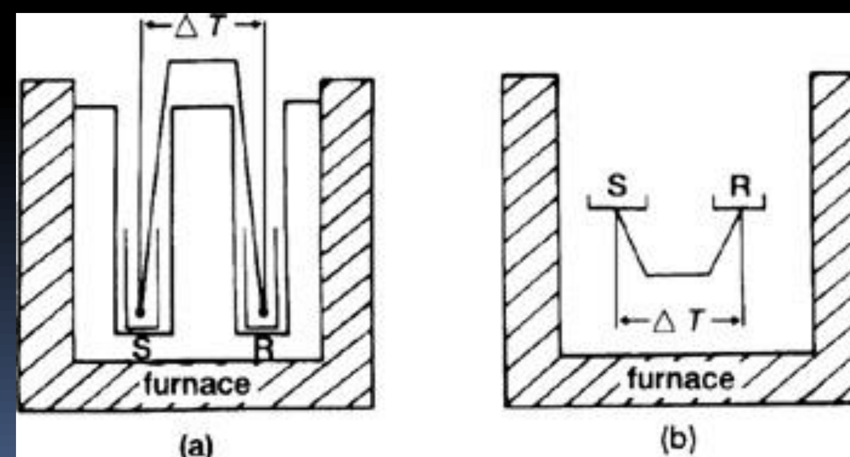
Compensation DSC



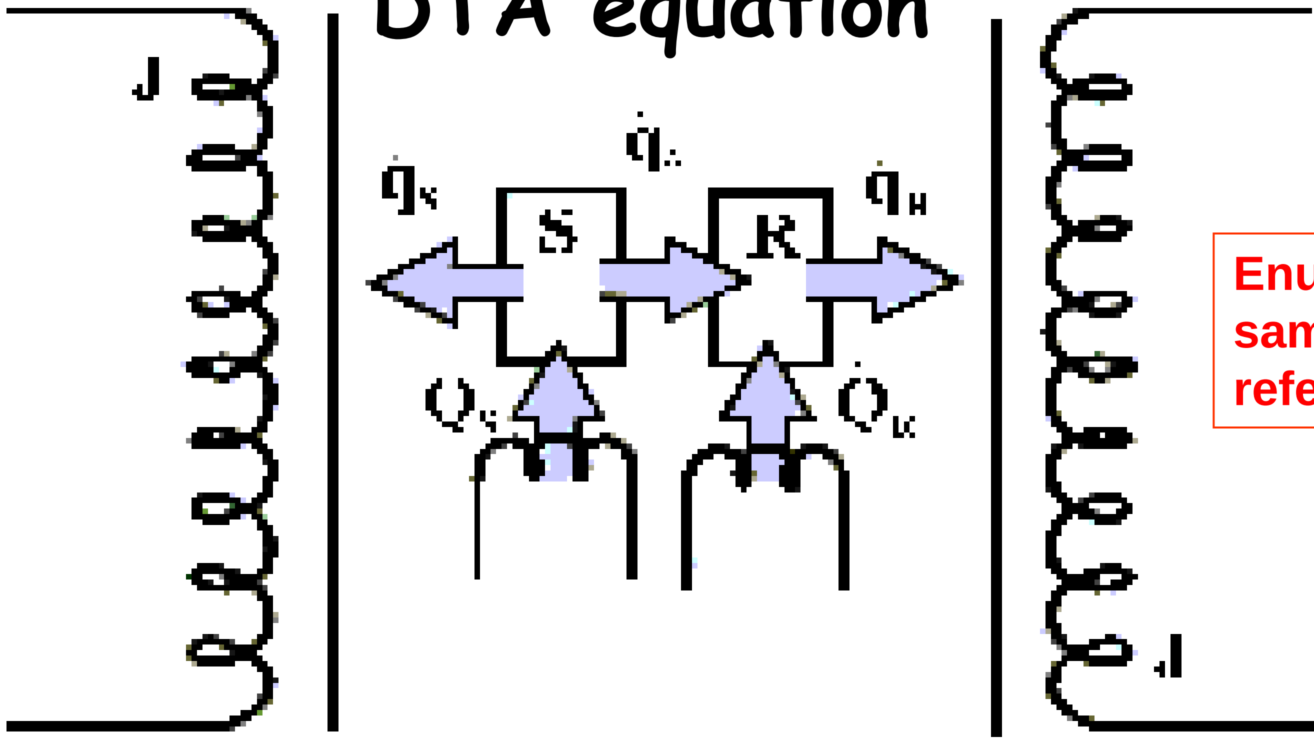
DTA







DTA equation



Enumerated for both the sample, s, and the reference, r,

DTA

$q'_s = \Lambda_s (T_s - T_j)$

$q'_\Delta = \Lambda_\Delta (T_s - T_r)$

$\Delta H'_s = q'_s + q'_\Delta + Q'_s$

$\Delta T = [- \Delta H_S \, \alpha' + (C_{pS} - C_{pR})\phi + C_{pS} \, \Delta T'] / \Lambda_S$

DSC

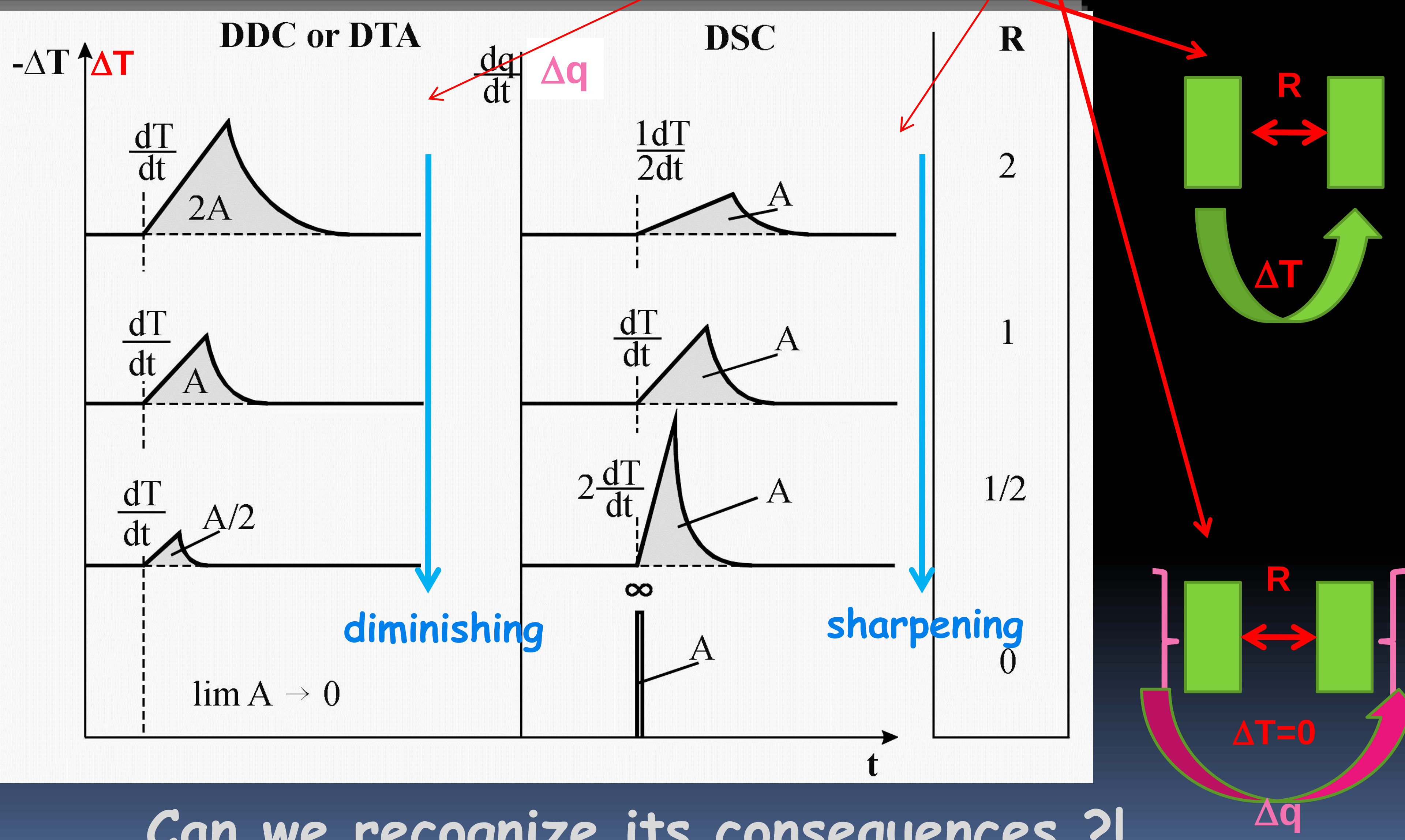
$(T_s \simeq T_r)$ and $\Delta T_{DTA} \approx 0$

$\Delta Q' = - \Delta H_s \, \alpha' + (C_{ps} - C_{pr})\phi + \Delta \Lambda (T - T_j)$

Šesták J, Holba P (2013) Heat inertia and temperature gradient in the treatment of DTA peaks: Existing on every occasion of real measurements but until now omitted. J Thermal Anal Calorim 113: 1633–1643

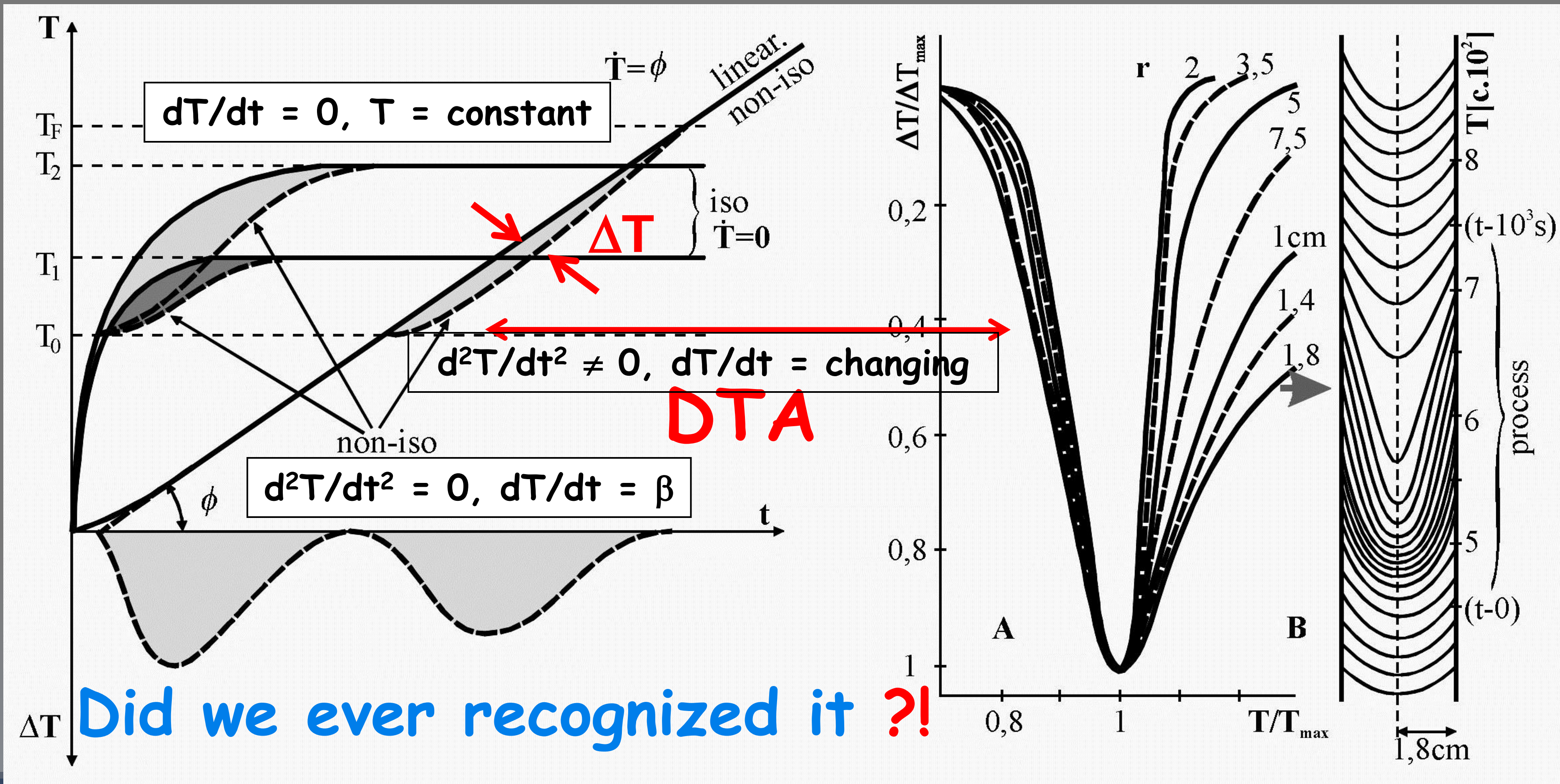
Why are the curves/peak by DTA and DSC different ?

Mutual comparison of the sensitivity of measurements



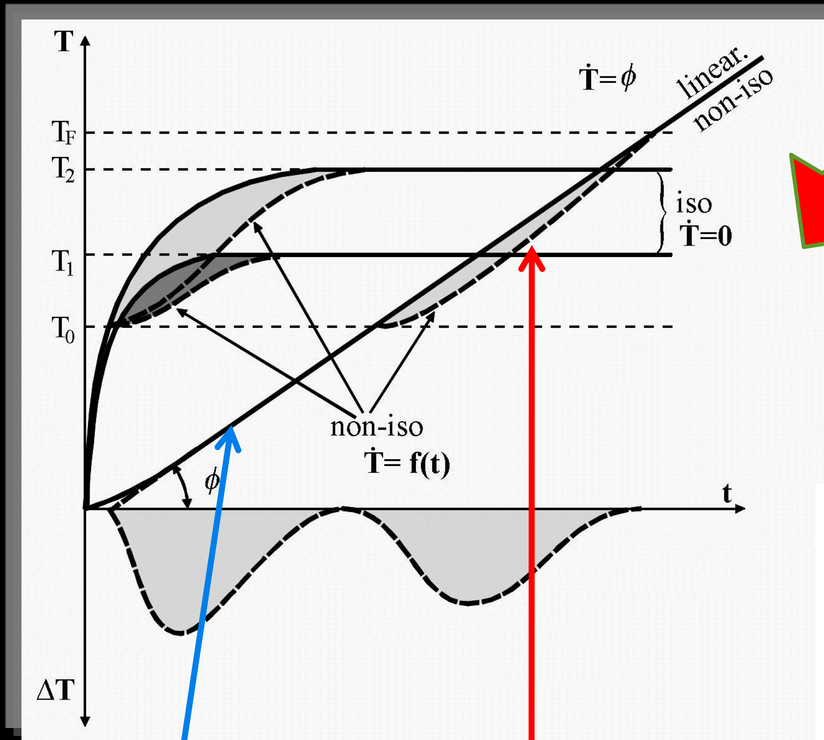
Can we recognize its consequences ?!

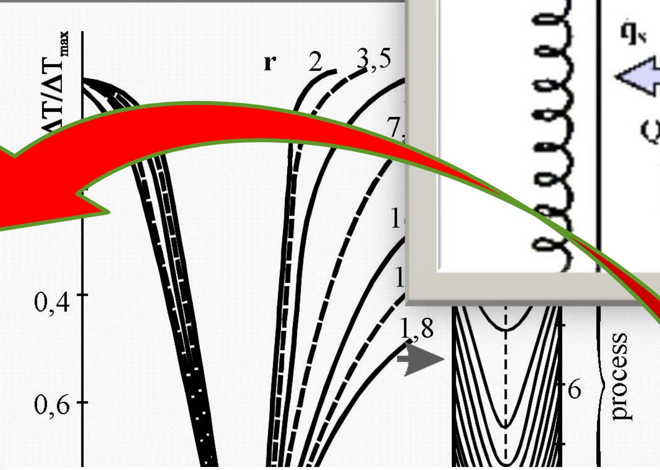
Isothermal and non-isothermal measurements: naturally involves thermal setups-gradients

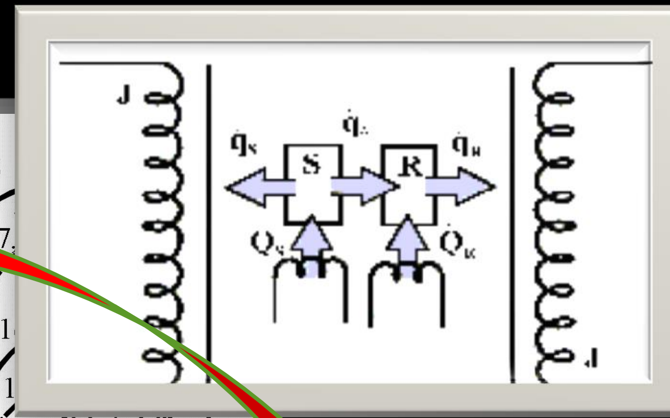


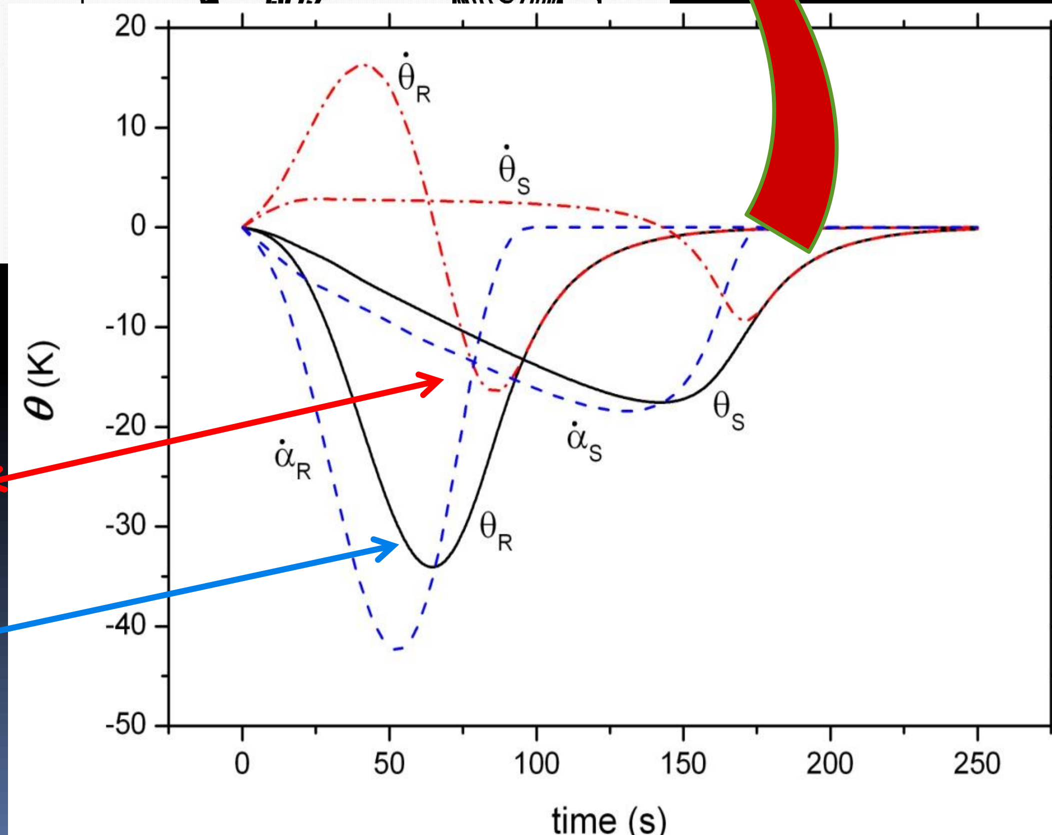
Did we ever recognized it ?!

Holba P, Šesták J. (2015) Heat inertia and its role in thermal analysis. J Thermal Anal Calor, 121:303–307





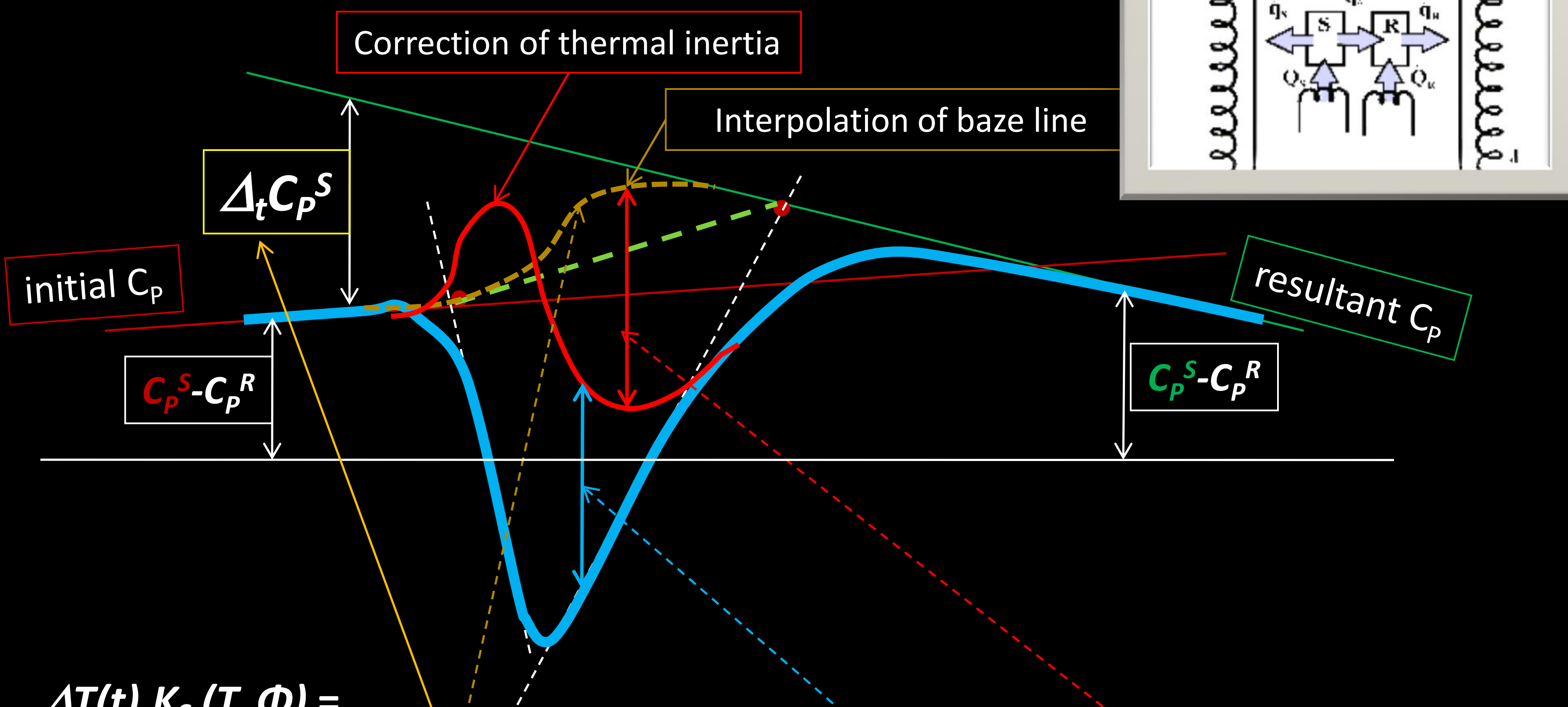




Relate to the peak background temperature

Relate to linearly increasing external temperature of heated furnace

DTA CURVE



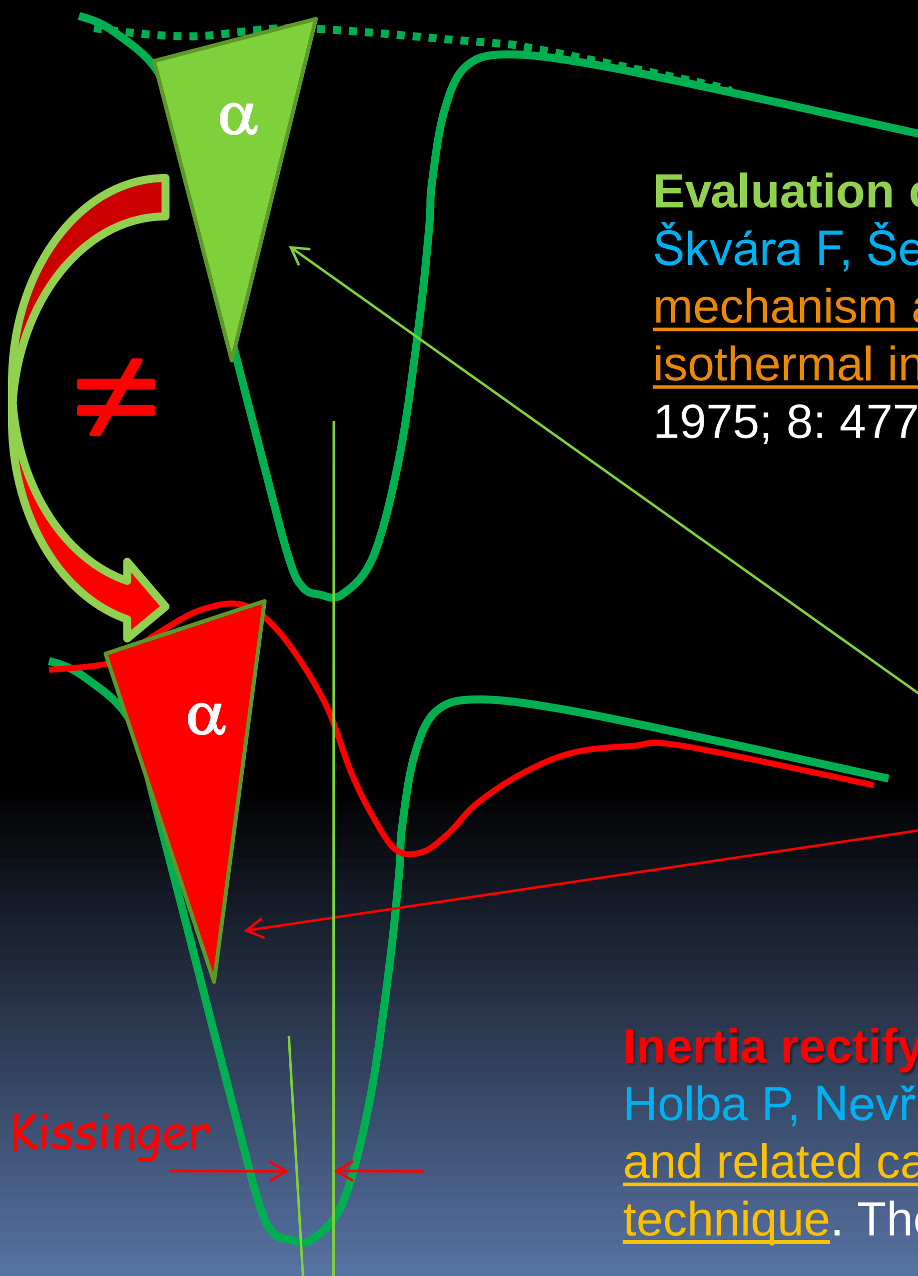
$$\Delta T(t).K_S(T, \Phi) =$$

$$= \Delta K(T_O - T_R) - \Delta C_P \Phi + \Delta_t C_P^S (1-\alpha)(\Phi + d\Delta T/dt) - \Delta_t H^S (d\alpha/dt) - C_P^S (d\Delta T/dt)$$

Thermal capacity of sample

DTA equation

Effect of heat inertia on kinetic evaluations



Evaluation of kinetics and mechanism by SQUEST
Škvára F, Šesták J. Computer calculation of the mechanism and associated kinetic data using a non-isothermal integral method J. Thermal Anal. Calor. 1975; 8: 477-489

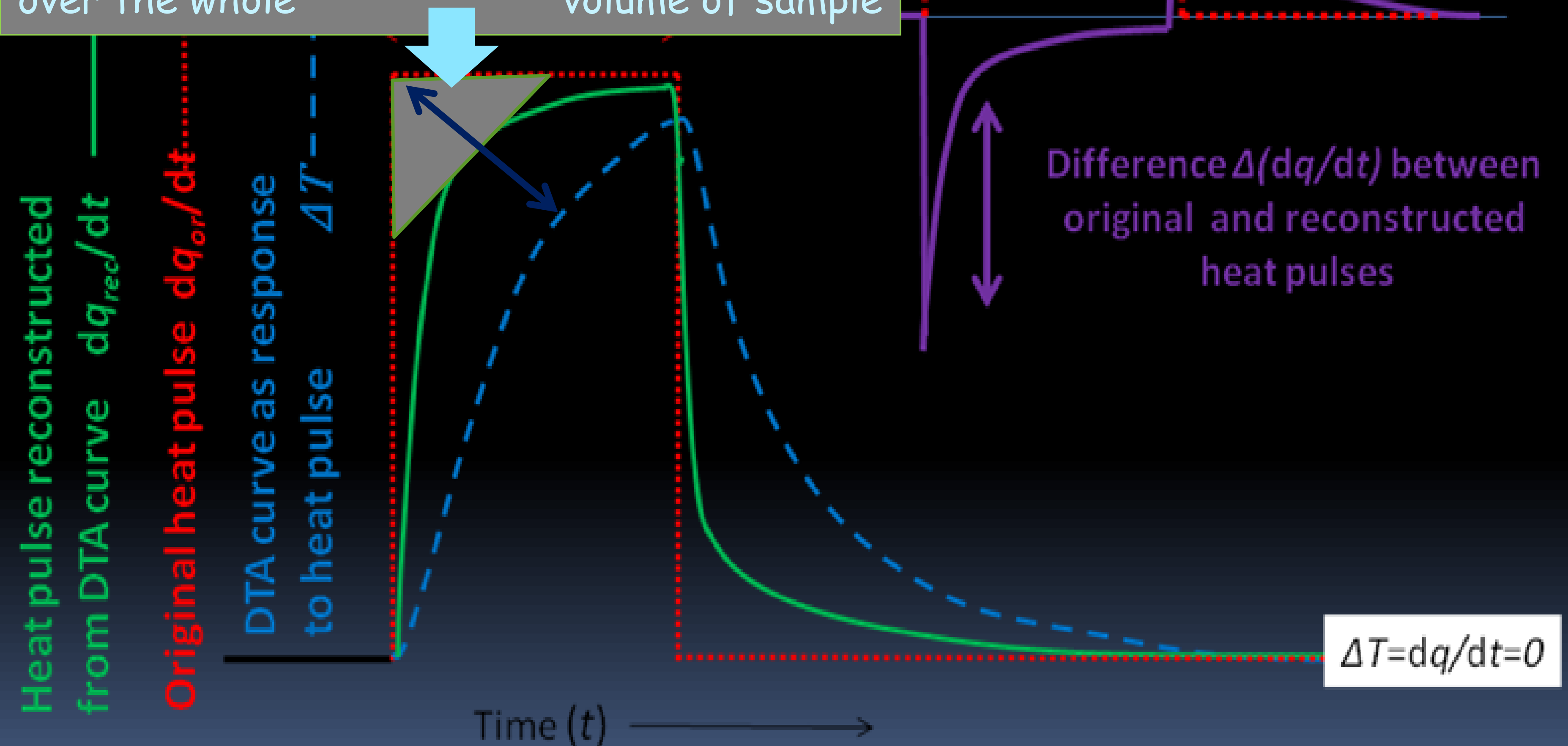
Phase transition of $BaCO_3$ at 810° C

ΔH	E [cal]	mechanism
613	118	A3
617	52	A3

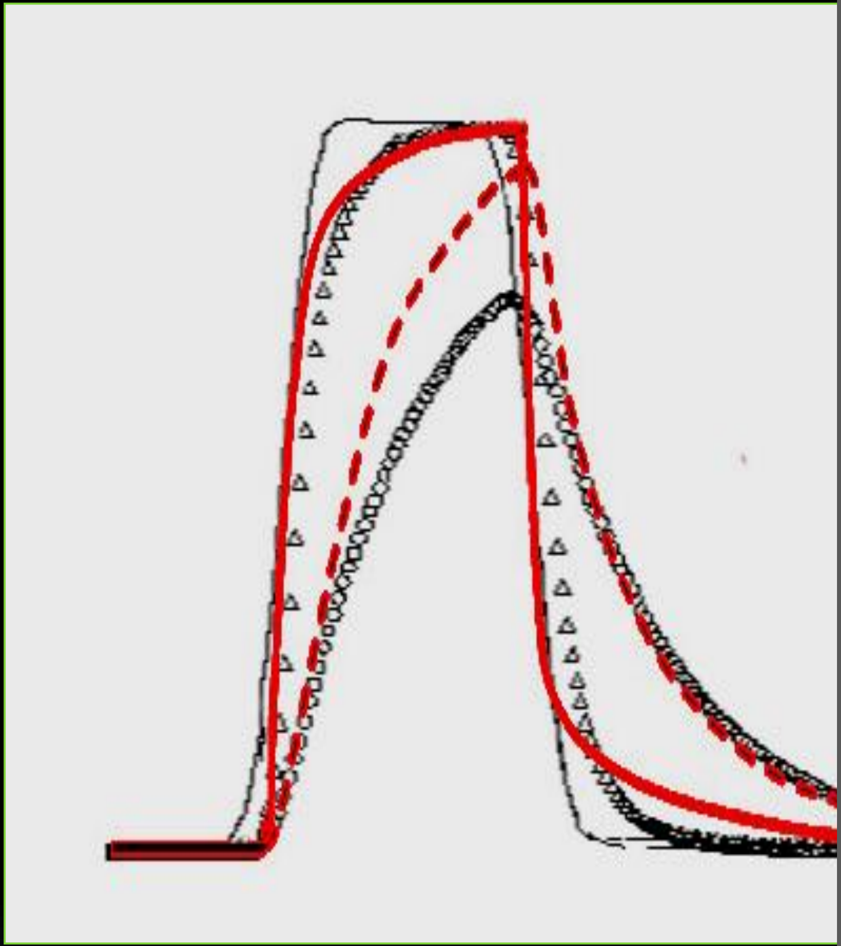
Inertia rectifying evaluation program by ALANTA :
Holba P, Nevřiva M,. Šesták J. Analysis of DTA curve and related calculation of kinetic data using computer technique. Thermochim. Acta 1978; 23: 223-231.

Practical approval and T-gradients

Gradient rectification by introducing an additional correction term respecting the changes in temperature field inside the sample $d\theta_{SM}/dt$, where θ_{SM} is the difference between the surface-measured temperature and the temperature averaged over the whole volume of sample



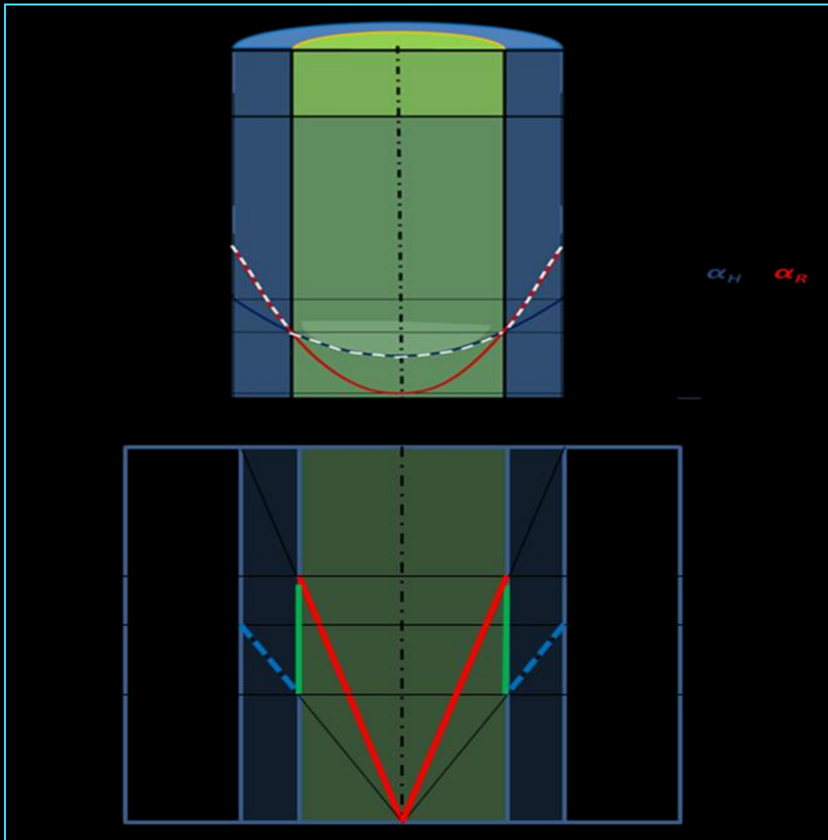
Holba P, Šesták J (2014) Imperfections of Kissinger evaluation method and crystallization kinetics. Glass Physics Chemistry. 40: 486–49

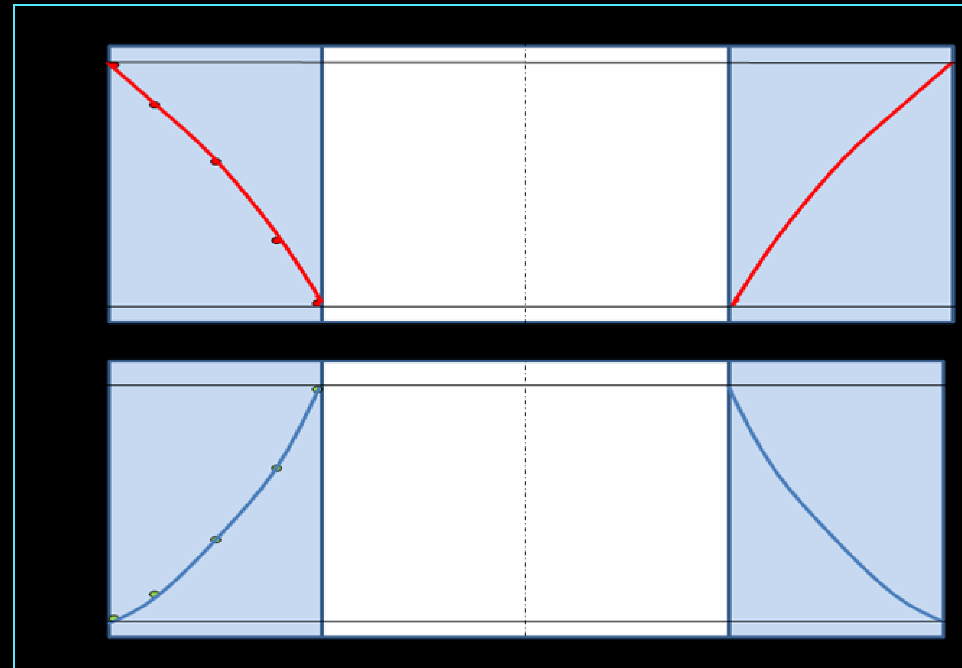


Holba P, Šesták J, Sedmidubský D (2013) Heat transfer and phase transition at DTA experiments. Chapter 5 in: Thermal analysis of micro-, nano- and non-crystalline materials (J. Šesták, P. Šimon. Eds), Springer, Berlin, pp. 99-134

A rectangular heat pulse was inserted into the sample by either method: (a) circles - the resistant heating inside the sample under the mode of linear heating and (b) triangles - the heat irradiation on sample surface during the isothermal regime. Both pulses are normalized on the <ΔT vs. t> axis as to fine-tuning the same shape. The as-measured DTA response on the internally inserted pulses (dashed read line, resistant heating) was corrected on the heat inertia effect by differential method to yield the rectified peak (full red line). The as-measured DTA feedback on the externally applied heat-pulse (small-circle line) was corrected by the standard Netzsch instrumental software based on integral method giving a rectified peak (small-triangles line). Both rectifications emerge the matching character of corrections. The upper left area between rectified peak and inserted rectangular pulses results from yet uncorrected temperature gradients in the sample

Temperature profiles

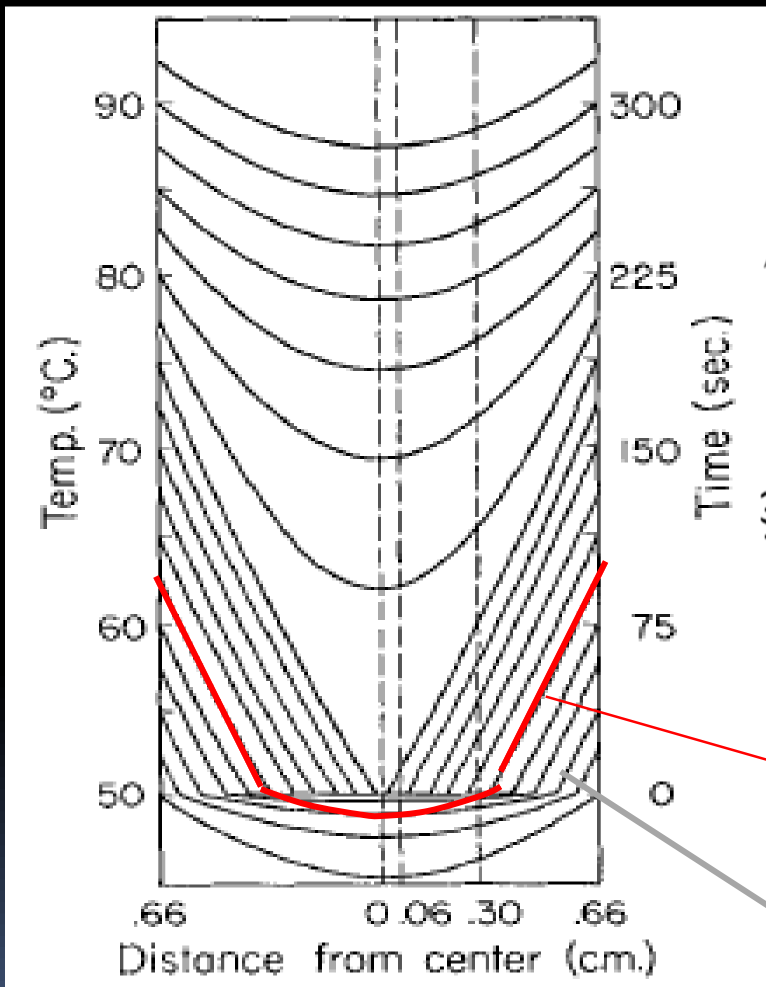




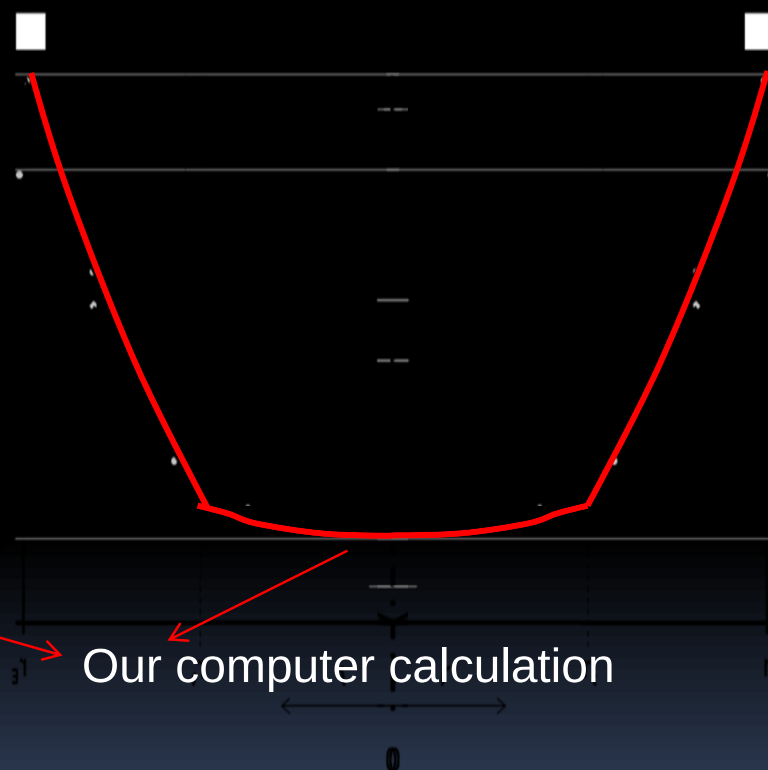
Stabilized temperature profiles $T_R(r)$, $T_H(r)$ and gradient profiles $g_R(r)$, $g_H(r)$ at linear heating ($\Phi_{RE} > 0$) in an infinite cylinder with external radius of holder (jacket) r_H and external radius of reference (core) r_E in the case when the thermal diffusivity of holder material a_H is greater than that of the reference material a_R ($a_H > a_R$).

Stationary temperature profile $T_R(r)$ and gradient profile $g_R(r)$ in hollow cylinder with outer radius r_E and inner radius r_I separating outer reservoir with temperature T_E and inner reservoir with temperature T_I

Temperature profile according to Smyth compared with our continual model utilized by computer calulus



1951 data



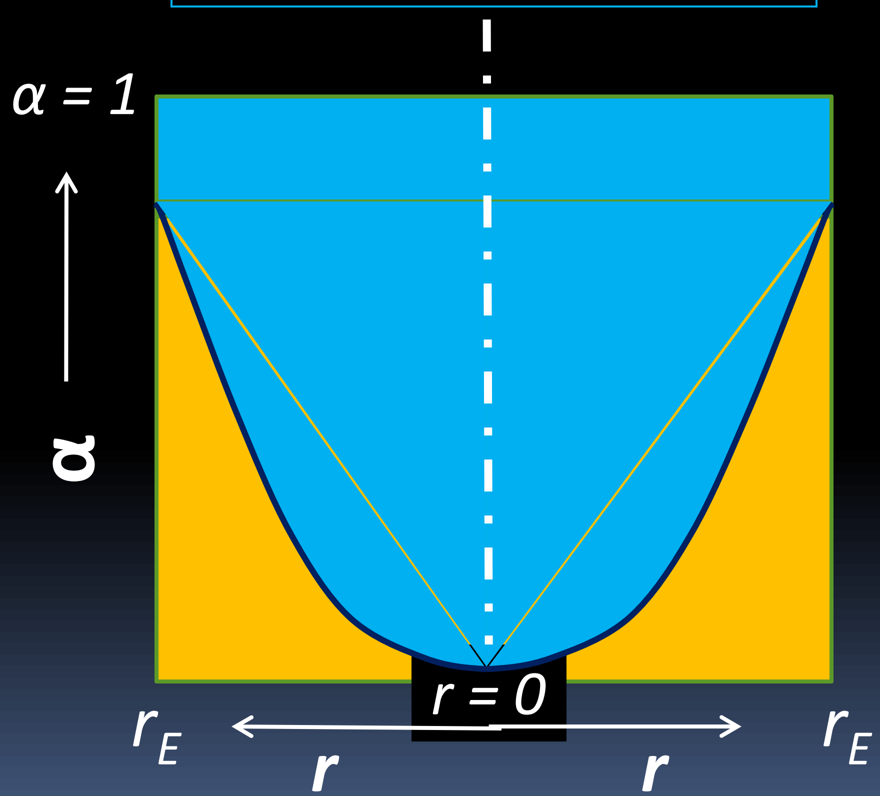
Our computer calculation

Smyth HT. Temperature Distribution during Mineral Inversion and Its Significance in DTA. J. Amer. Cer. Soc. 1951; 34: 221-224.

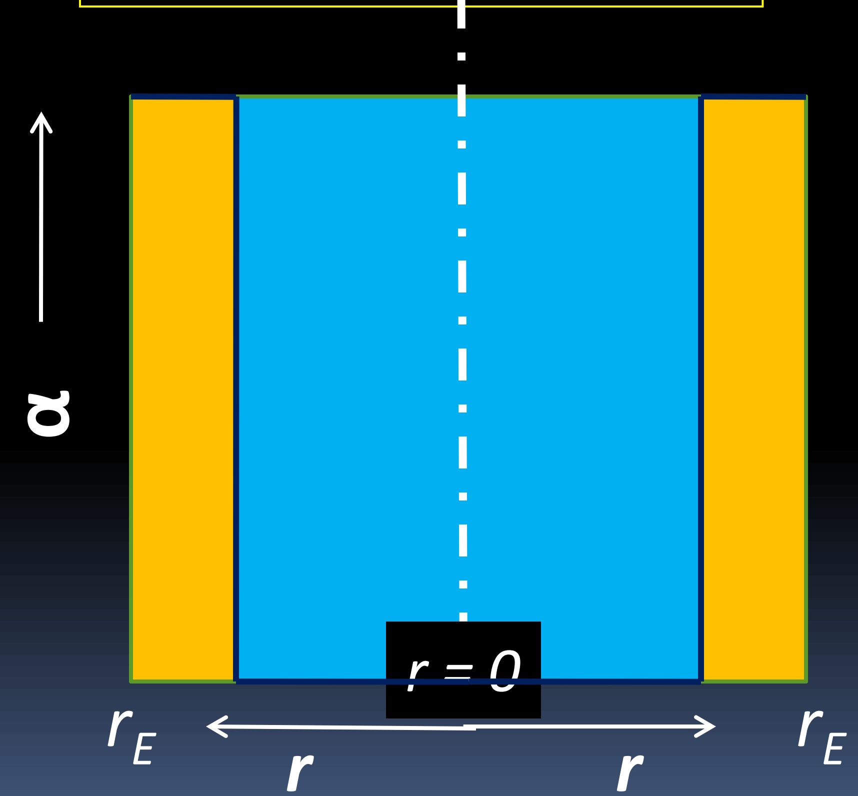
Kinetic models of a phase transition

(initial) **(final)**

Continual model:



Discontinual model:

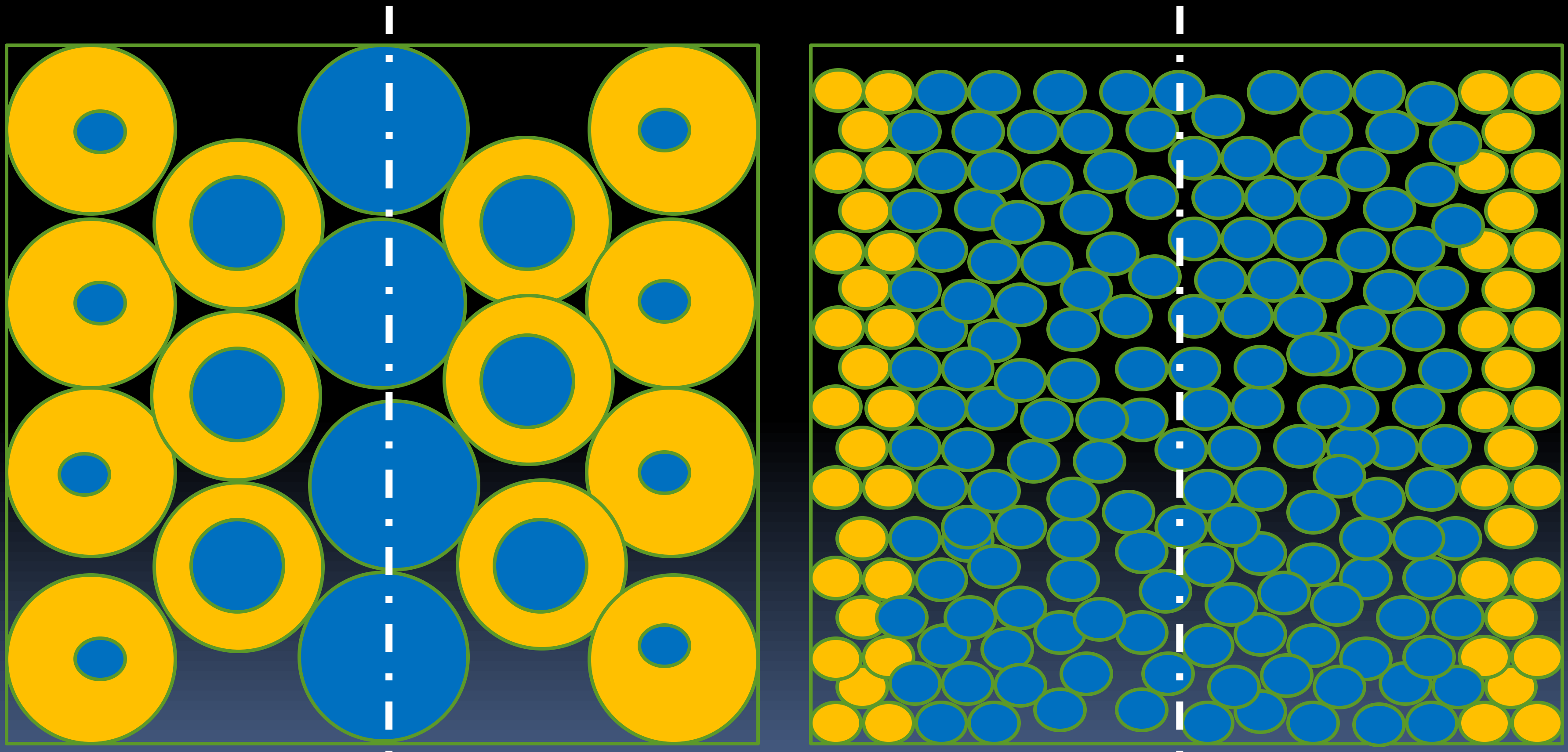


Courtesy by Pavel Holba

Variants of kinetic models of a phase transition

(initial) `& (final)

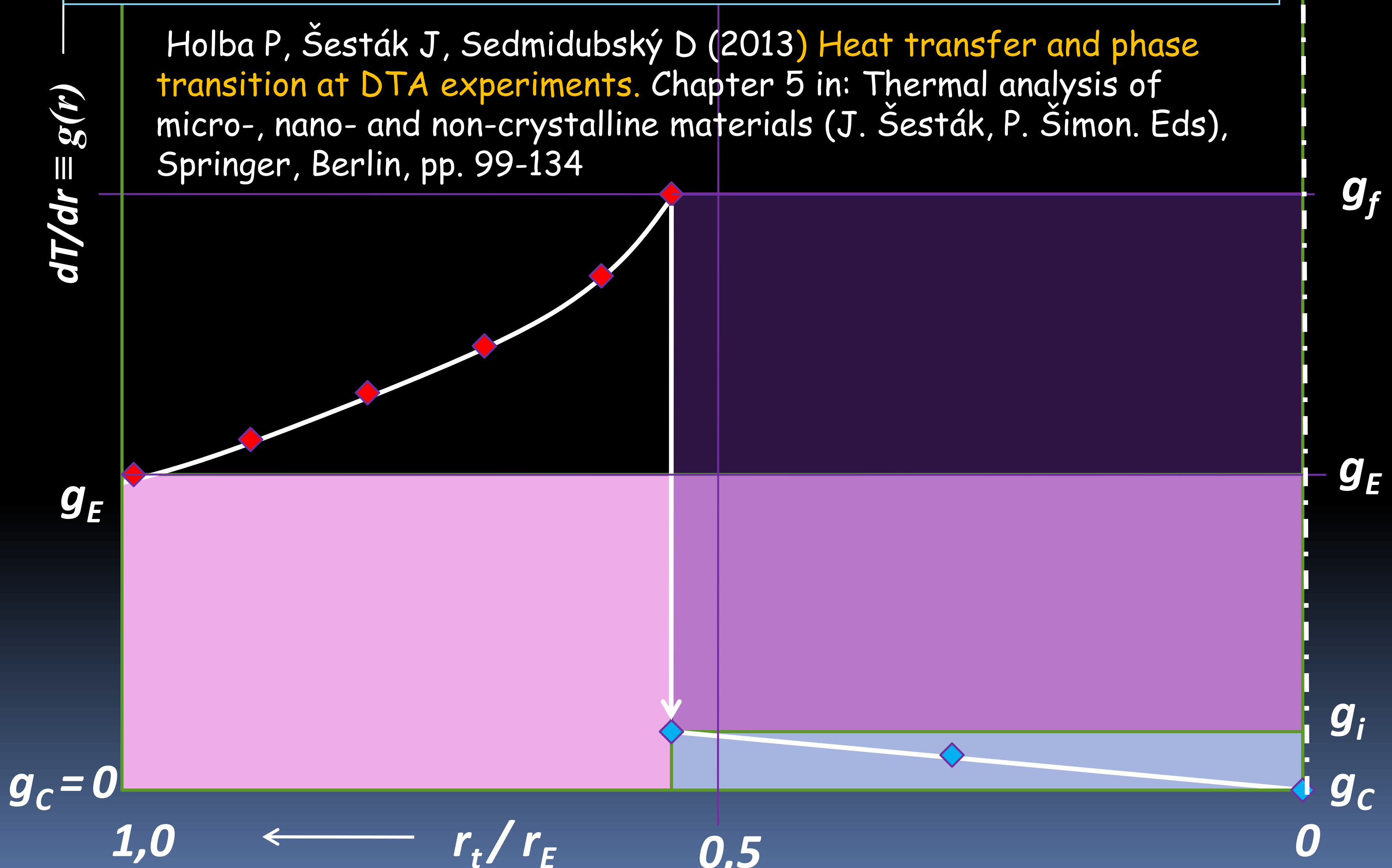
continual model: **Discontinual model:**



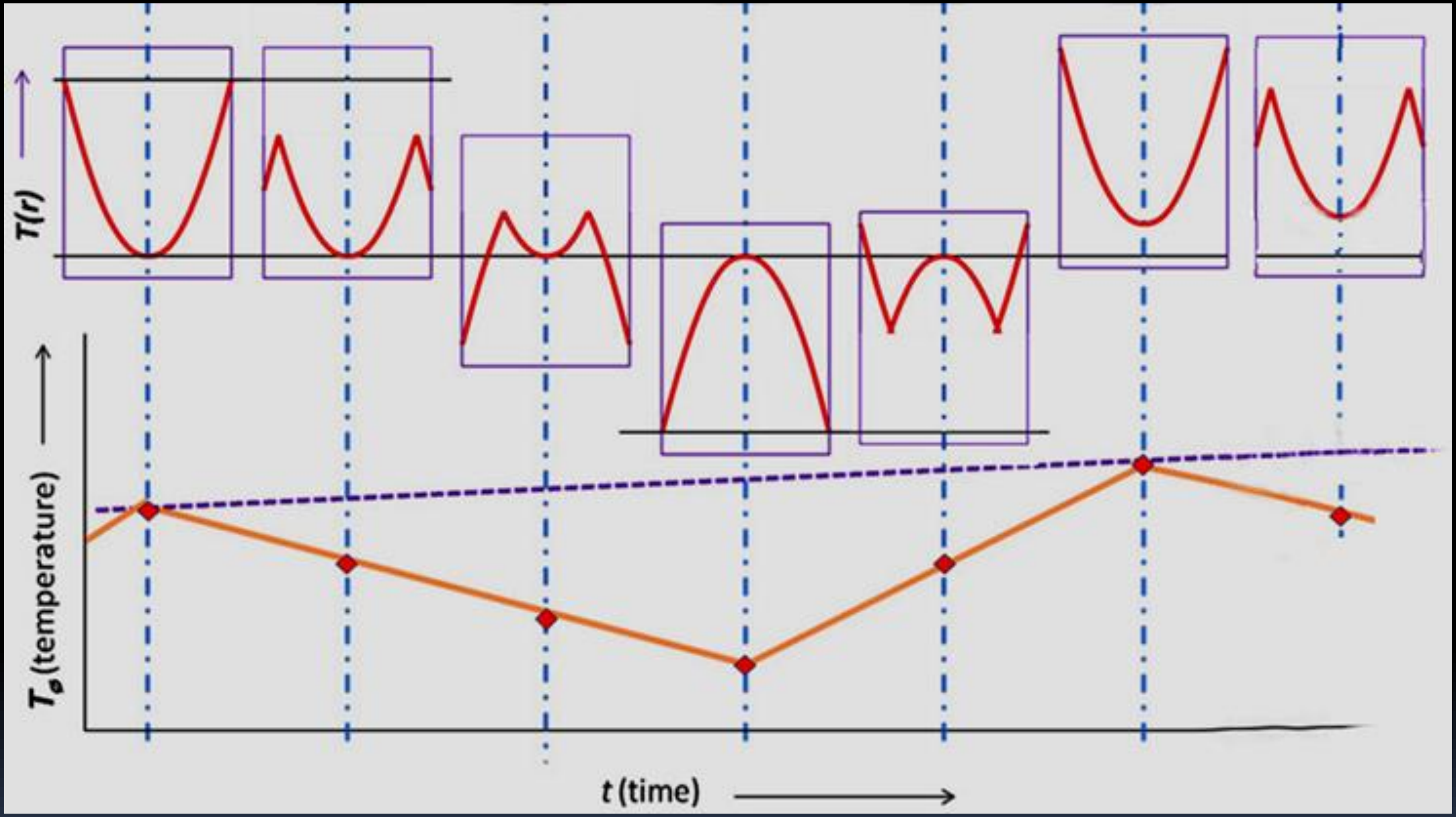
Courtesy by Pavel Holba

Profile of temperature gradient in the sample at the degree of transition ξ = 0.7 assuming a discontinued model

Holba P, Šesták J, Sedmidubský D (2013) Heat transfer and phase transition at DTA experiments. Chapter 5 in: Thermal analysis of micro-, nano- and non-crystalline materials (J. Šesták, P. Šimon. Eds), Springer, Berlin, pp. 99-134



Thermal gradients appear everywhere even during small temperature alternations in modulated thermal analysis



Holba P, Šesták J, Sedmidubský D (2013) Heat transfer and phase transition at DTA experiments. Chapter 5 in: Thermal analysis of micro-, nano- and non-crystalline materials (J. Šesták, P. Šimon. Eds), Springer, Berlin, pp. 99-134

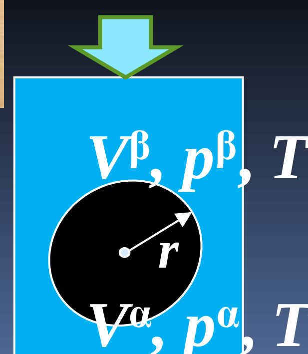
What is temperature under extremes?

Size and speed matters

Macro extreme
astrophysics

Extreme
temperature
changes

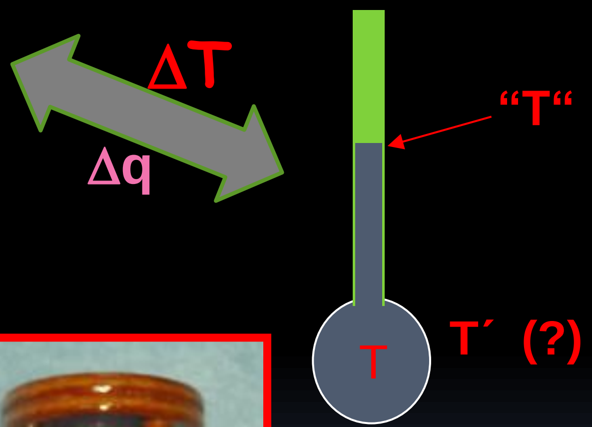
Micro extreme
nanophysics



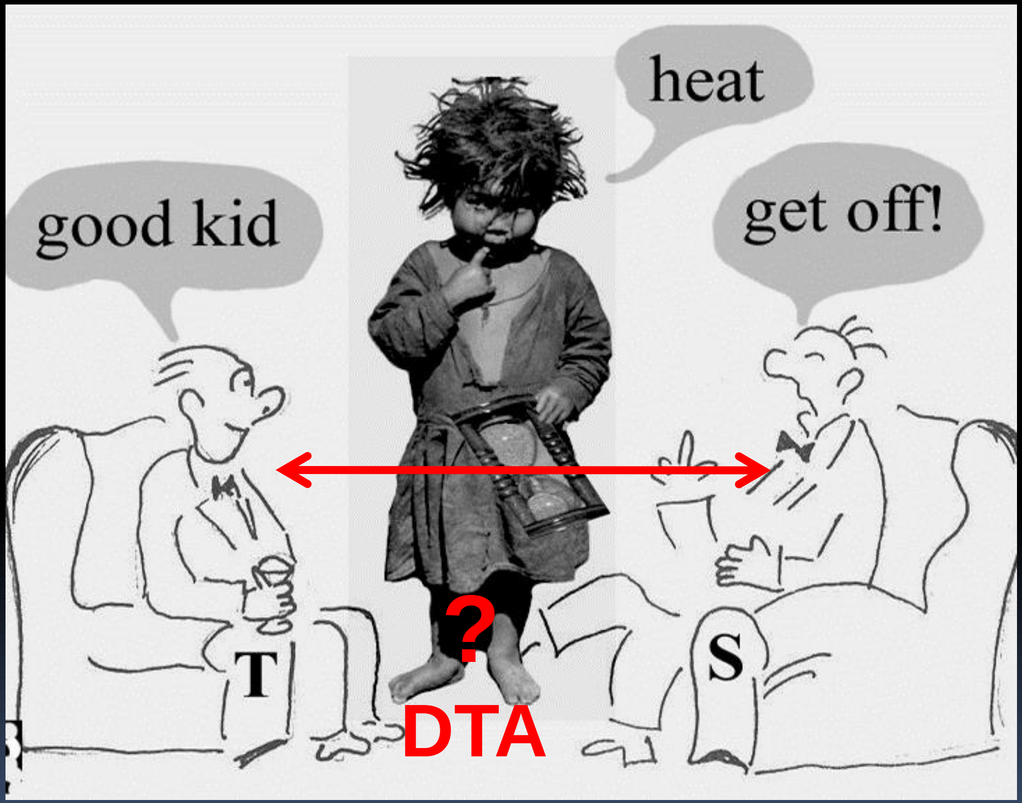
Current study exploring dimensionality changes, impact of surface tension

Ultra-fast processes - what is temperature contrivance of thermodynamics

What happens if there is no time for the system fast-enough equilibration?



⇓ Thermostatics Heat transfer Thermotics ⇓



what says "each thermodynamics" ?

Not knowing well the thermal nature in a classically arranged sample we are seeking for yet novel methods applying more and more complex regimes

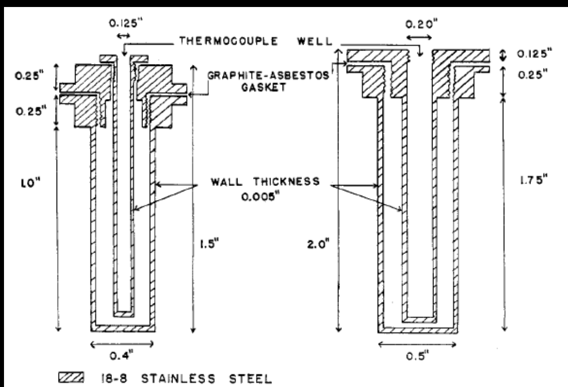
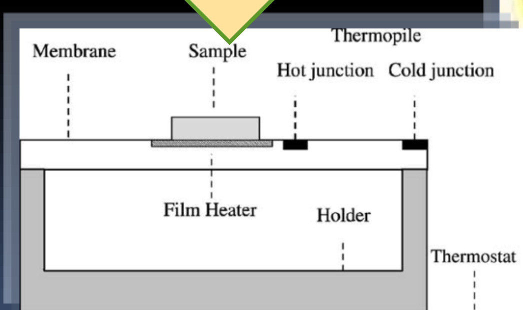
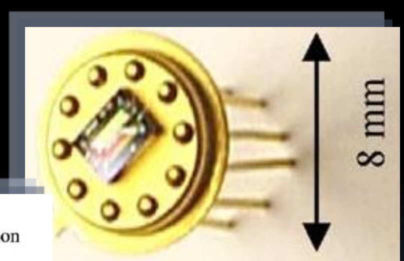
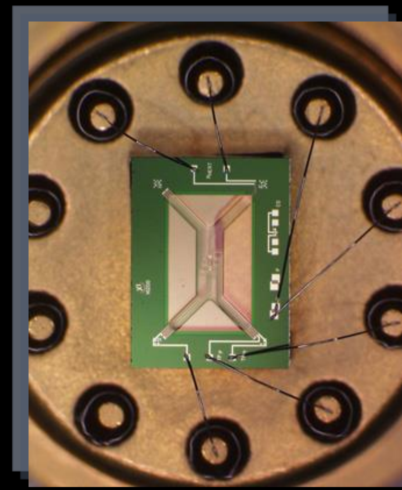


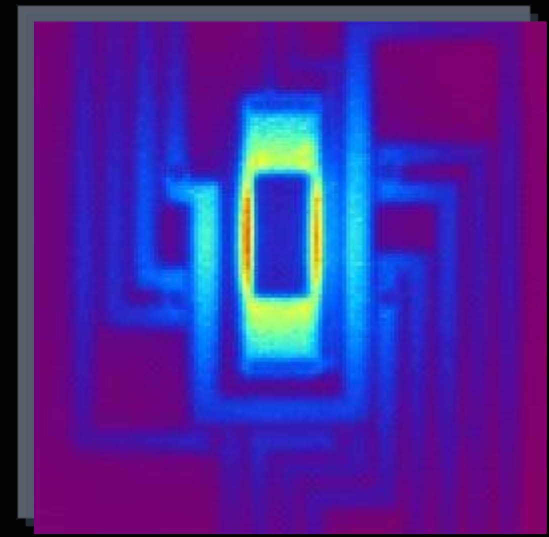
Figure 2. Differential Calorimeter Cells

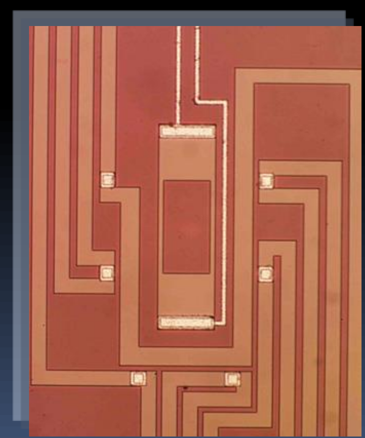
MICROCHIPS







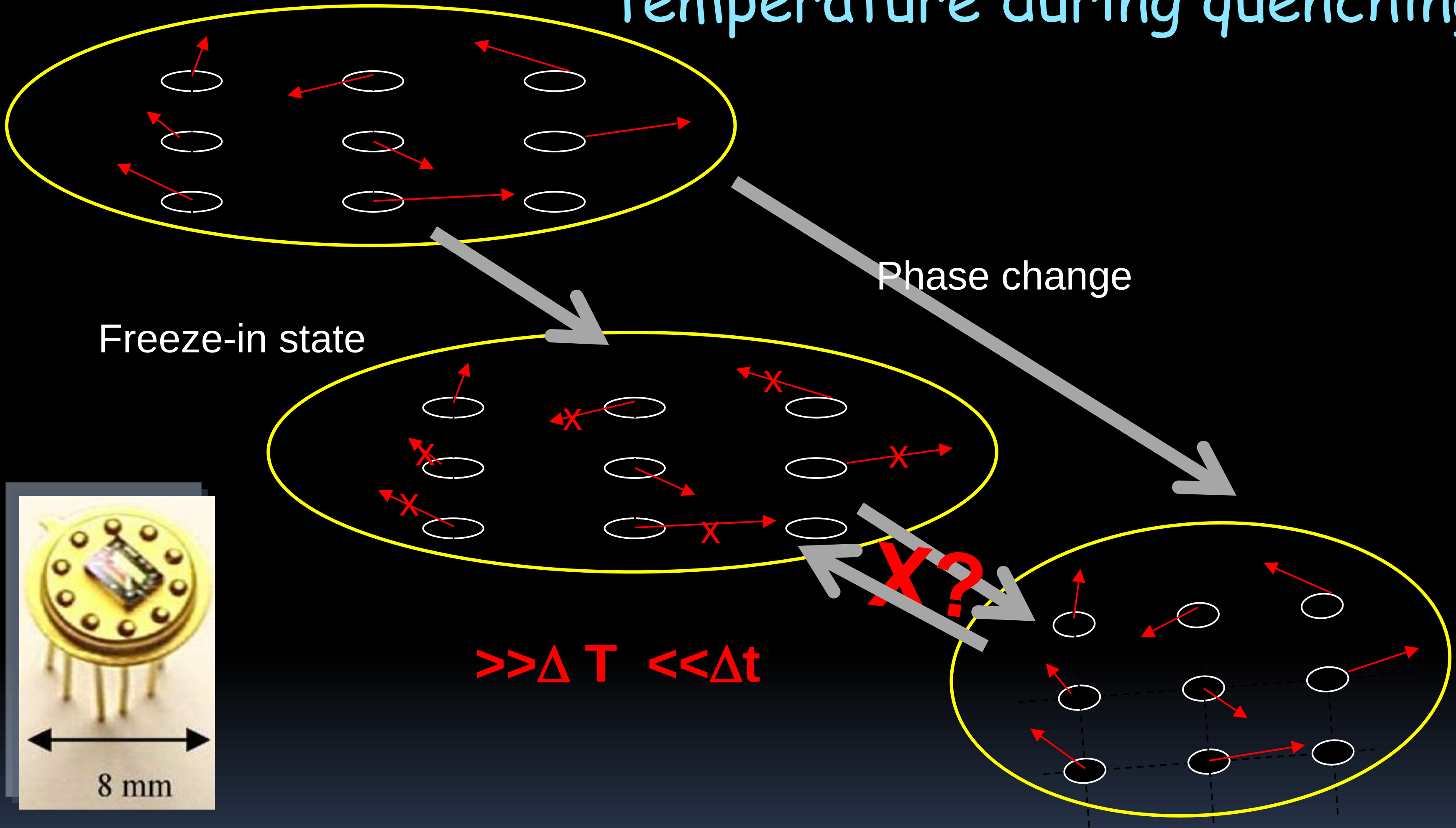




Amplitude of the radiation intensity *I (x, y) measured at* ac heating (2 V, 1 Hz). Dashed line A indicates the direction at *y1 = −24 μm along which the dependence I (x, y1) was measured.*

S.A. Adamovsky, A.A. Minakov, C. Schick. *Scanning microcalorimetry at high cooling rate*. Thermochimica Acta 403 (2003) 55–63; and: *Ultra-fast isothermal calorimetry using thin film sensors* Thermochimica Acta 415 (2004) 1–7

Special case of a change:
temperature during quenching

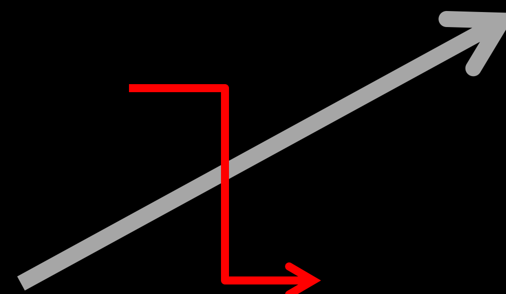


Šesták J (2016) Measuring "hotness", should the sensor's readings for rapid temperature changes be named "tempericity"? J Therm Anal Calorim 125: 991–999
Holba P (2016) Šesták´s proposal of term „tempericity“ for non-equilibrium temperature and modified Tykodi´s thermal science classification with regards to methods of thermal analysis. J Therm Anal Calorim. 2016

Temperature -tempericity of ultrafast changes (in nano-scale) and its determinability

$\Delta q \, \Delta T$ = ?Δ?

Where is the operate limit of uncertainty principle



$\Delta T / \Delta t$ = ?Δ?

Where is the operate limit of ever recordable temperature changes

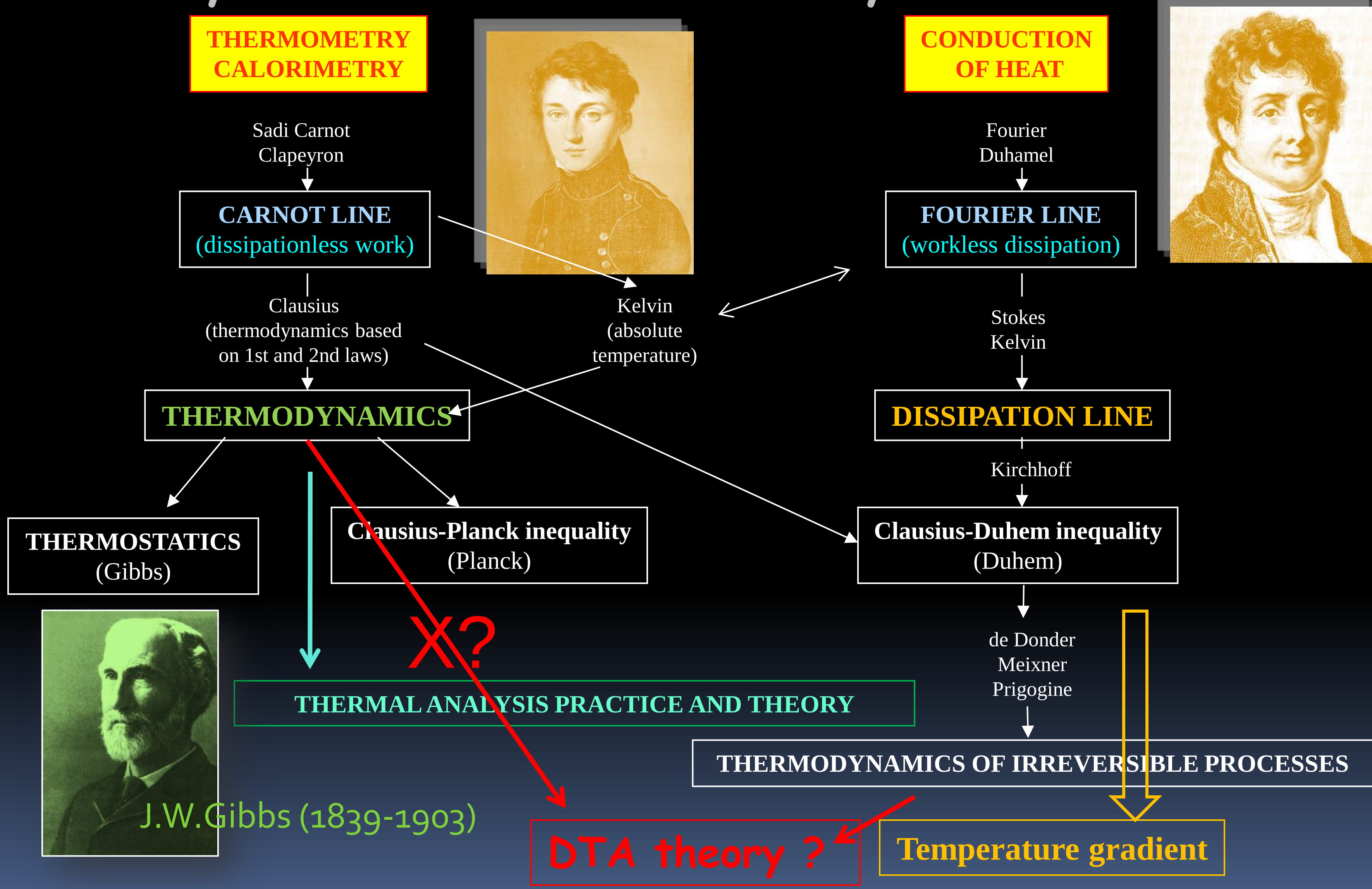
ΔT = ?Δ?

Where is the limit of readable and reproducible temperature gradient

B. Wunderlich (2007) "Calorimetry of Nanophases "Int.J. Thermophysics 28 958-96

Šesták J. (1979) Thermodynamic basis for the theoretical description and correct interpretation of thermoanalytical experiments. Thermochim Acta; 28: 197-227

Thermodynamic approach through the detailed analysis of family tree of existant thermodynamic subdivisions:



Holba P, Šesták J., (1976) "Theory and practice of DTA/DSC" Silikáty (Prague) 20: 83 (1976; and Quantitative evaluation of thermal effects: theory and practice. Annali di Chimica 67: 73 (1977)

Thermodynamic approach needing an extension for true non-equlibriums studies

THERMOMETRY CALORIMETRY	CONDUCTION OF HEAT	COMPLEX IMPACTS
Sadi Carnot Clapeyron	Fourier Duhamel	*William Whewell (1794-1866)*
CARNOT LINE (dissipationless work)	**FOURIER LINE** (workless dissipation)	**TYKOLDI LINE** **thermo-dynamics**
Clausius (thermodynamics based on 1st and 2nd laws)	Stokes Kelvin	*Ralph Tykodi (1925-2009)*
THERMOSTATICS (Gibbs)	**Clausius-Duhem inequality** THERMODYNAMICS of irreversible processes	**THERMOTICS TERMOKINETCS**
$dT/dt = 0$, $T = \text{constant}$	$d^2T/dt^2 = 0$, $dT/dt = \beta$	$d^2T/dt^2 \neq 0$, $dT/dt = \text{changing}$

Temperature — **Tempericity**

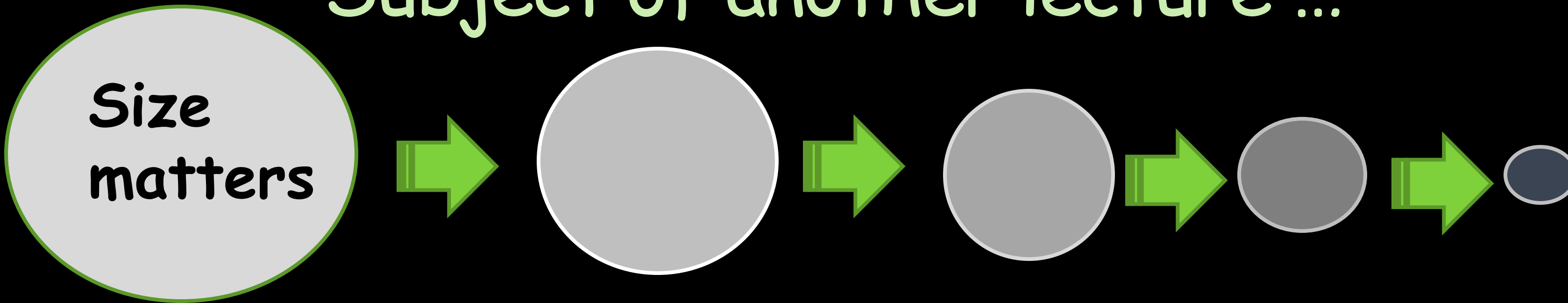
Tempericity → DTA theory ? ; Tempericity → **Temperature gradient**

Šesták J (2013) Thermal science and analysis: Terms connotation, history, development, and the role of personalities. J Therm Anal Calorim 113:1049–1054

Yet uncertain territory of thermodynamics

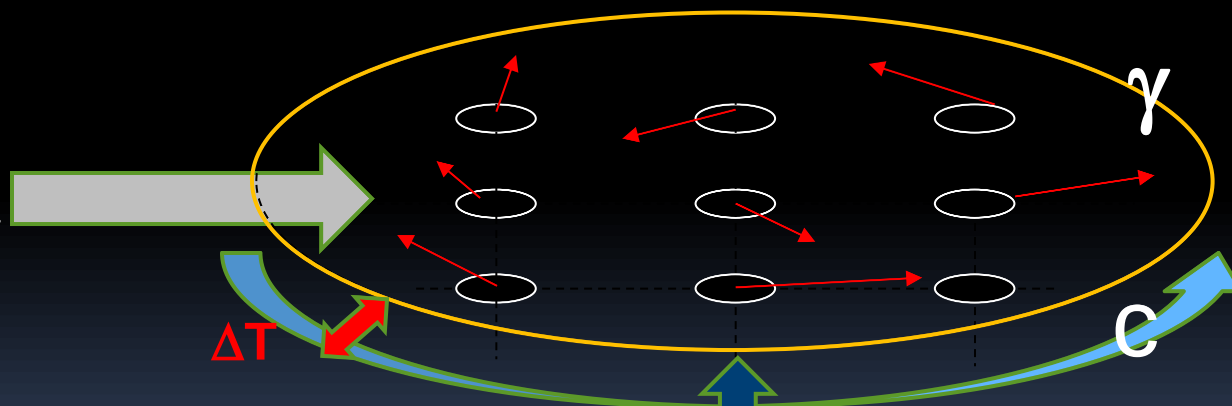
Corrections toward nano-scale progression ?

Subject of another lecture …



At macroscopic scales: the Laws are perfectly valid for statistical systems but what happens at nano-scales (curved interfaces γ and **c**)?

Decreasing number of bulk molecules to a nano-limit narrowed by interface layer energy and curvature



$T_{non\text{-}eq} = T_{eq}\ (2V\,\gamma/(\Delta H\, r)$

Interaction between the sample holder (cell) and the entire sample surface

rivalry between the bulk ~ r^3 and surface ~ r^2

Quandary for diminutive bringing on micro/nano-analysis methods by using:

* ultra-small samples and
* mili-second time scales .

It involves a further peculiarity of truthful temperature (T_r versus T_∞) measurements of nano-scale crystalline samples in the particle micro range with radius (**r**) which becomes size affected due to increasing role of the surface energy usually described by an universal equation:

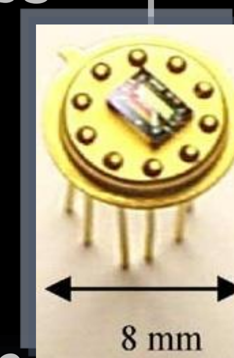
$$T_r/T_\infty \cong (1 - C/r)^p$$

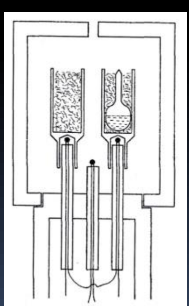
where ∞ portrays a standard state and **C** and **p** are empirical constants ranging $\approx 0.15 < C < 0.45$ and $p = 1$ and/or $\frac{1}{2}$

Šesták J. (2015) Kinetic phase diagrams as a consequence of radical changing temperature or particle size. J Thermal Anal Calor, 120: 129;

Any experiment always provides certain data on temperature and other measured variables ⇒ sensor´s reading !

It seems that thermoanalysts believe that a mere replacement of thermocouples by thermocouple batteries or by highly sensitive electronic chips moreover renaming DTA principle to variously termed DSC´s is a sufficient solution toward theoretical rations.





It's the responsibility of researcher to know to what extent spans his true conscientiousness!

One never gets to see that his work is so secret that he does not even know what he is doing ! (~allied to blindness trust to instrumental outputs)

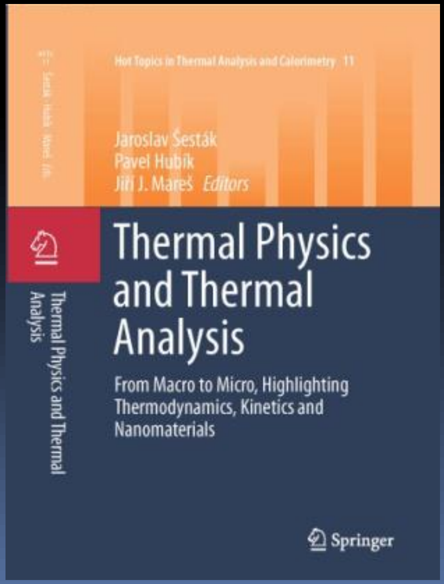
inspirational links to Pavel Holba (1940-2016) legacy again

Pavel měl svoji logiku, v našem kabaretu ´Major Kopřiva´ říká:

…aby se nemohl oheň rozšířit na odlehlejší místa, musí se nádoby se stlačeným plynem a veškeré hořlavé kapaliny neprodleně umístit do centra požáru!!…

a svá pozorování třídil podle principu:

….že každá myšlenka má poločas rozpadu, kdy se stává blbostí a naopak, každá blbost se po čase stává myšlenkou!!…



Chybíš nám Pavle !!

Díky za slyšení!