

关于如何理解物理量熵的若干思考

吴国玠¹, 皇甫泉生²

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热力学作为物理学最难理解的一门分支学科,其改革与创新至关重要。通过热力学与电学之间的类比,引入了基于直觉认知的热荷和热荷量的概念,由此得出**熵就是热荷量**这一简单而明确的定义。其结果是,熵 热荷量 与热量这两个不同性质的物理量得以清晰地区分开来(前者是一种能量载体,而后者则是能量本身),从而不仅消除了热力学的抽象性,而且还消除了熵这个物理量之前在概念上的模糊性。以全新的面貌出现的热力学不但有利于我国广大科研和工程技术人员理解、掌握、应用和创新,有利于提升我国的科技软实力,而且也有利于大、中学生的物理教学和热力学知识的普及。

熵;热荷;热荷量;卡尔斯鲁厄物理教程;物质型物理量;类比

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Considerations on how to Understand the Physical Quantity Entropy

WU Guobin¹, HUANGFU Quansheng²

(1. School of Energy and Power Engineering, University of Shanghai for Science and Technology, Shanghai 200093, China;

2. College of Science, University of Shanghai for Science and Technology, Shanghai 200093, China)

Abstract: It is critical for thermodynamics, the most difficult branch of physics, to be reformed and updated. Through the analogy between thermodynamics and electricity, the concepts of thermal charge and quantity of thermal charge were introduced in an intuitive way, from which a simple yet explicit definition was derived — **entropy is the quantity of thermal charge**. As a result, the two quantities, i.e. entropy (quantity of thermal charge) and the quantity of heat can be clearly distinguished. The former is an energy carrier while the latter is in fact energy itself. This eliminates not only the abstractness of thermodynamics but also the fuzziness of the original concept of entropy. These new ideas for thermodynamics are expected to make it easier for our scientists and engineers to understand, apply and innovate, and therefore to enhance China's soft power in science and technology. Also, it should be beneficial to our physics teaching in both universities and high schools, as well as to the popularization of thermodynamic knowledge.

Keywords: entropy; thermal charge; quantity of thermal charge; Karlsruhe Physics Course (KPK); substance-like quantity; analogy

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1972

Job

[2]

entropy as heat

Herrmann

[3] Der Karlsruhe Physikkurs **KPK**

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[1]

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[5-6]

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Tab.1 Analogy between major branches of physics

分支学科	广延量	强度量	流强度	能流
电学	电荷量 Q	电势 φ	电流 $I=dQ/dt$	$P=\varphi I$
力学	动量 p	速度 v	动量流 $F=dp/dt$	$P=vF$
热学	熵 S	温度 T	熵流 $I_S=dS/dt$	$P=TI_S$

2 KPK

2.1
KPK

$$I_S = \frac{\Delta S}{\Delta t}$$

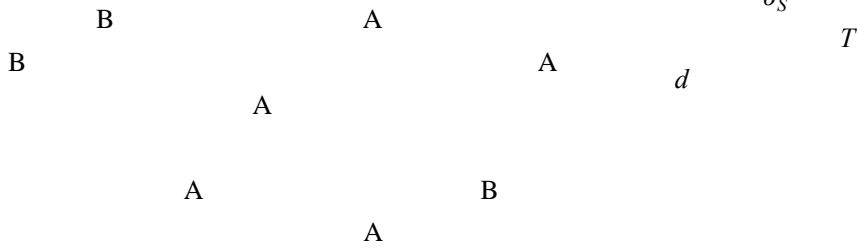
$$I_S = \frac{dS}{dt} \quad (1)$$

Ct/s

" " " "

" " quantity of heat " " heat [7]

$$I_S = \sigma_S A \frac{\Delta T}{d} \quad (2)$$



2.3

[3]

2.2

$$P = \Delta\varphi I$$

P
I φ

$$P = \Delta T I_S$$

[3]

$$P = T I_S \quad (3)$$

2.4

E T

$$dE = T \cdot dS \text{ 或 } dS = \frac{1}{T}dE$$

$$\Delta S = \int_r dS = \int_r \frac{dE}{T}$$

" r" reversible

δQ

dE
 δQ

Q
 dQ

δQ dE

" " " "

$$\int_r \frac{dE}{T} = \int_r \frac{\delta Q}{T}$$

KPK

S

S_{Cl}

$$\Delta S = \Delta S_{Cl} \quad (4)$$

" "

KPK

" "

3

2.5

KPK

entropy

1865

1923

entropy

KPK

" "

" "

Q T

KPK

1990

KPK

[2, 8]

2010

KPK

S 3

S_{Cl} KPK

KPK

$$P = T I_S$$

$$\frac{dE}{dt} = T \frac{dS}{dt}$$

KPK

" " [8]

" " " "

KPK "

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KPK

Job

KPK " "

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4

" "

KPK " "

electric charge

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thermal charge

KPK

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" " " "

" " " "

1

2

KPK " "

KPK "

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" "

KPK

quantity of electric charge

"

Q

C

quantity of thermal charge

S

0

Ct

1 cm^3

4

Ct

[3]

2

Tab.2 Analogy between thermodynamics and electricity

5

分支学科	广延量	强度量	流强度	能流
电学	电荷量 Q	电势 φ	电流 $I=dQ/dt$	$P=\varphi I$
热力学	热荷量(熵) S	温度 T	熵流 $I_S=dS/dt$	$P=TI_S$

19

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KPK

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18

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1860

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Job

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KPK

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05Q JWCPI " [. "FWCP "Z "H. "NKGDGT "E "O0 "Pcpqyktgu "hqt
kpvgi tcvgf "o wnvkeqnt "pcprj qvqkpeu]L_0" Uo cnn."4227."3*3+<
36463690

06QRCP "C"N. "NKW" "T"D. "UWP" "O" "J. "gv"cn0"Urcvkn"eq o rqukvkq
itcfkpi "qh "swcvgtptct{ "\pEfUUG "cnnq{ "pcpqyktgu "ykvj
vwpcdng"nki jv" g o kuukq"dgvyggp"572"cpf"932"p o "qp" c"ukping
uwdvtevg]L_0"CEU" Pcpq."4232."6*4+<"89368:20

07Q \ JWCPI "Z "L. "PKPI "E "\. "RCP "C "N0 "Eq o rqukvkq"cpf
dcpf icr/itcfgf "ug o keqpfwevqt "cnnq{ "pcpqyktgu]L_0
Cfxcpegf"Ocvgtkcnu."4234."46*3+<"356550

08QRCP "C"N. "\ JQW" "Y"E. "NGQP "I" "G" "U" "R. "gv"cn0"Eqvkwqwu
cnnq{ /eq o rqukvkq "urcvkn "itcfkpi "cpf "uwrgrtdtqcf
yxcngnpi vj/vwpcdng "pcpqyktg "ncugtu "qp "c"ukping "ejkr]L_0
Pcpq"Ngwgtu."422;.; *4+<"9:669: :0

09Q IW "H" "Z. " [CPI "\ [. " [W "J "M. "gv"cn0"Urcvkn "depficr
gpi kpgtkpi "cnpq "ukping" cnnq{ "pcpqyktgu]L_0" Lqwtpcn "qh" vjg
C o gtkecp" E jg o kecn "Uqekgv{ ."4233."355*9+<"42596425;0

O:O TGKOGTU "R0 "Vjg "rtgrctevkq"qh "itcfgf/dcpf/icr "ukping
et{ uvcnu "qh "KK/XK "eq o rqpwf]L_0" Rj {ukec "Uvevwu "Uqnkfk "*"d+.
3;8;."57*4+<"92969380

O:O TGKOGTU "R. "TWRRGN" "Y0 "Vjg "rtgrctevkq"qh "EfU/EfUg
itcfgf "ukping"et{ uvcnu]L_0" Rj {ukec "Uvevwu "Uqnkfk "*"d+."3;8:.
4;*3+<"M536M550

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Dncem¹⁵⁻ 3979

i:~n

082Q IW "H" "Z. "\ J CPI "N. "\ J W " ["D. "gv"cn0"Htgg/urcegeqwrnkpi
qh"pcpqcpvppcu"cpf" y jkurgtkpi /icmgt{ "o ketqecxkvkgu"ykvj
pcttqygf "nkpgykvfvj "cpf "gpjcpegf "ugpukvkvxk]L_0" Ncugt " (
Rj qvqkpeu" Tgkgyu."4237."; *8+<"8:468: :0

083Q IW "H" "Z. "EWK "J "D. "NKCQ "H. "gv"cn0"Oqfg "vcknqtkpi "kp
uwdyxcngnpi vj/fk o gpukqpcn "ug o keqpfwevqt "o ketql
pcpqyxcgi wkfgu"d{ "eqwrnkpi "qrvkecn" o ketqhkdg]L_0" Qrvkeu
Gzrtguu."4238."46*42+<"455830

084Q OC "N. "J W "Y. "\ J CPI "S "N. "gv"cn0" Tqq o /vg o rgtcvwtg
pgct/kphtctgf "rjqvqfgvgevqt"dcugf"qp"ukping"jgvtqlwpevkq
pcpqyktgu]L_0" Pcpq"Ngwgtu."4236."36*4+<"8;668; :0

085Q IWQ"R" "H. "J W "Y. "\ J CPI "S "N. "gv"cn0"Ug o keqpfwevqt" cnnq{
pcpqtdddq "ncvgtn "jgvtqvwtvewvtgu "hqt "jki j /rgthqt o cpeg
rjqvqfgvgevqt]L_0" Cfxcpegf "Ocvgtkcnu."4236. "48*3+<
4:6664:6;0

086Q IW "H" "Z. "\ J CPI "N. " [KP "Z "H. "gv"cn0" Rqn { ogt "ukping/
pcpqyktg "qrvkecn "ugpuqtu]L_0" Pcpq "Ngwgtu."422:." :;*+<
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087Q IW "H" "Z. "ZKG" "H" "O. "NKP "ZKP I. "gv"cn0"Ukping" y jkurgtkpi /
icmgt{ "o qfg "ncukpi "kp "rqn { ogt "dqwnng "o ketqtguqpcvqtu
xc "urcvkn "rwor "gpikpgtkpi]L_0" Nki jv< "Uekpeg " (
Crnkcevkqpu."4239."8<"g392830

05Q JGTTTOCPP"H0"

* +/ "]O_0" ." 0" <
."42320

06Q 0"
]L_0" ."4233."43*5+<"656730

07Q ." 0" *MRM+
]L_0" ."4234."53*32+<"646670

08QHCNM "I. "TWRRGN" "Y0 "Gpgtikg"wpf "Gpvtqrk"]O_0" Dgtnkp<
Urtkpi gt"Xgtnci."3;980

09Q JGTTTOCPP "H0 "Fgt "mctnutwjgt "rj {ukmmwtu "gkp "ngjtdwej
hwt "fgp "wpvgttkejv "kp "fgt "ugmwpfctuwgh "KK "]O_0 "Dgtnkp<
CWNKU"Xgtnci."422:0

O:ORQJNKI "O. "TQUGPDGTI "L0 "Vjtg "ejcpegu "hqt
gpvtqr{]L_0" Ncvkp "C o gtkec "Lqwtpcn "qh "Rj {ukec "Gfwecvqk.
4234."8<"6;67:0

08Q JGTTTOCPP"H0"]L_0" O:Q] _ ."] _ 0"]O_0
." 0" ."4232*67+0 ." 0" < ."3; ;;0

04QLQD" I0" "]O_0" ." 0" ." 0" <
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