SUN COMMISSION REPORT

Document SUN 56-7

The following report of the Commission for Symbols, Units, and Nomenclature of the International Union of Pure and Applied Physics represents an extension of the Commission's report "Symbols and Units" (Doc. UIP 6) which was reproduced in the November 1956 issue of Physics Today. *The present document is carried at the request of the SUN Commission in order that American physicists might be informed of its contents prior to the meeting of the US National Committee of IUPAP in May and the IUPAP General Assembly in September. It should be noted that publications of the American Institute of Physics continue to follow the usages indicated in the AIP* Style Manual. *Comments concerning this report should be sent to the chairman of the SUN Commission, Prof. H. H. Nielsen, Department of Physics and Astronomy, The Ohio State University, Columbus, Ohio.*

THE Commission for Symbols, Units, and Nomenclature (SUN Commission) met in Paris (March 20–23, 1956) in the Institut d'Optique. All the members of the Commission were present, namely: H. H. Nielsen (USA, president), E. A. Guggenheim (Great Britain), E. Perucca (Italy), A. Perard (France), J. Rossel (Switzerland), E. Rudberg (Sweden), U. Stille (West Germany), and J. de Boer (Netherlands, secretary).

At the last meeting of the IUPAP in London it was decided that, in order to make possible a detailed examination of the proposals of the SUN Committee before submitting these to the General Assembly for approval, the SUN Commission should have a meeting not only during the General Assembly of the IUPAP, but also one year or more in advance, so as to prepare the recommendations and to make possible a distribution to the national committees *before* each general assembly of the IUPAP.

The present report summarizes the conclusions of the discussions in the SUN Committee and contains also the recommendations (numbered 1, 2, 3, etc.) which will be presented to the General Assembly in Rome in September 1957.

After the publication of the report "Symbols and Units" of the IUPAP one of the important problems is how to guarantee a wide distribution of the recommendations contained in this document. Besides the actual distribution of copies of the report available at the general secretariate of the IUPAP in Paris, it is recommended to request different physics journals to reprint the report in full. The following journals have accepted this proposal: *Nuclear Physics, Il Nuovo Cimento, Journal de Physique, Nederlands Tijdschrift voor Natuurkunde*, and *Physics Today*.

The discussion of the SUN Commission had the purpose of extending and completing the recommendations contained in the report (Document UIP 6) "Symbols and Units." We will therefore follow the division in chapters used in that document to indicate the new proposed recommendations:

I. General Principles and Recommendations

Addition to Section 3:

Proposal 1: It is recommended to use the *decimal sign and the multiplication sign between figures or numbers* according to the following principles:

decimal sign:	, or .	(*only* in English texts)
multiplication sign between figures:	× or .	(*not* in English texts)

If this recommendation is followed by physicists no confusion could be possible because the point would never be used in one text both for decimal sign *and* for the multiplication sign between numbers. Also no recommendation would be necessary about the question whether to place the point on the line or halfway up. In English texts one thus *may use* the point or the comma as a decimal sign, but should use *exclusively* the cross as multiplication sign between numbers. *Example:* One may write: "The constant of Planck is $h=6.62\times10^{-27}$ ergs or also $h=6{,}62\times10^{-27}$ ergs." In non-English texts one should *exclusively* use the comma as decimal sign, but one *may use* the cross as well as the point as multiplication sign. *Example:* One may write: "La constante de Planck est $h=6{,}62\times10^{-27}$ ergs ou bien $h=6{,}62.10^{-27}$ ergs"! The recommendation follows the actual usage in the different countries: In all Europe except England the comma is used for the decimal sign; in England and the USA the point is used.

Addition to Section 4: The recommendations given in "Symbols and Units" are concerned only with the symbols for chemical elements. It was considered to be advisable to extend the recommendation to use upright (Roman) type for the symbols of chemical elements also to symbols which are used to indicate *particles*. Therefore the SUN Commission proposes:

Proposal 2a: It is recommended that *symbols indicating particles or quanta* should be written in upright Latin or Greek characters. *Examples:*

neutron	n
proton	$p={}^1H$
deuteron	$d={}^2H$
triton	$t={}^3H$
α-particle	$\alpha={}^4He$
π-meson	π
μ-meson	μ
electron	e
neutrino	ν
photon	γ

At the elementary particles conference in Bagnères de Bigorre a small group of specialists recommended some rules for indicating particles in general, which have now been adopted quite generally. Therefore the SUN Commission proposes, in agreement with the recommendations of Bagnères de Bigorre:

Proposal 2b: It is recommended that the following notation should be used:

Hyperons:	Y-particles; Upright capital Greek letters to indicate particular particles, e.g., Λ, Ξ, Σ
Nucleons:	N-particles; Upright lower case n and p to indicate neutron and proton respectively
Mesons:	K-particles; Upright lower case Greek letters to indicate particular particles, e.g., π, μ, τ, κ
Leptons:	L-particles; e.g., e, ν

[*That the above examples fail to reflect the complete spirit of the proposals is a result of the fact that the varieties of type available to publications of the AIP do not include* upright *lower case Greek characters.*—Ed.]

In addition to these recommendations the SUN Committee proposes:

Proposal 2c: It is recommended that the charge of particles may be indicated by adding the superscript +, −, or 0. *Examples:* π^+, π^-, π^0, p^+, p^-, e^+, e^-. If in connection with the symbols p and e no charge is indicated these symbols should refer to the positive proton and the negative electron respectively.

The indication ~ above the symbol of a particle has been used to indicate the antiparticle of that particle (e.g., $\tilde{\nu}$ for antineutrino) and it is recommended to use the same indications when needed in other cases.

New Section 5: One of the leading general principles of the SUN Commission has always been that physical quantities should be printed in sloping (italic) type and that other symbols, like chemical elements, numbers, mathematical operators, units, etc. are always printed upright (see "Symbols and Units" I, Sec. 1(1) and Sec. 2(1)).

Until now no general decision has been taken for symbols indicating the *quantum state* like ${}^2P_{1/2}$-state or s-electron, etc. About the indication of ${}^2P_{1/2}$ there exists already considerable agreement that this should be printed upright, but no such agreement exists about indications like s, p, d-electron or nucleon.

The SUN Commission considers it advisable to be guided by the general principle that physical quantities, i.e., quantities which may occur as a constant or variable in physical equations, *and only those*, should be written in sloping type. Consequently the SUN Committee proposes for the indication of a quantum state:

Proposal 3: It is recommended to print symbols, indicating the quantum state of a system or a particle in upright type. *Examples:* ${}^2P_{1/2}$-state, s-electron.

New Section 6: No general principle so far has been given for the printing of indices in upright or sloping type. The SUN Commission considers it to be of importance to *extend the rules, applied for printing the symbols themselves, also to the indices.* In m_{He} or m_e, the indices He and e should be printed upright. In S_g or C_s, the indices indicating "gas" and "solid" should be upright. However in C_p the index p, being the symbol for the pressure, should be sloping (italic). A case which might be considered somewhat dubious is that of running indices in an equation like $\psi=\Sigma_n a_n \varphi_n$. Also here, however, the indices n represent physical quantities (without dimension in this case) or quantum numbers or sets of quantum numbers, which may occur in physical equations as variables and thus should be printed in sloping (italic) type. A recommendation about this subject should certainly only be considered as a guiding principle or working rule which might bring some order in a field where up till now no general rule exists. Therefore the SUN Commission proposes:

Proposal 4: It is recommended to consider as a guiding principle for the printing of indices the criterion:
only indices which are symbols for physical quantities should be printed in sloping (italic) type.

Examples:

Upright indices:		*Sloping indices:*
C_{g}	(g=gas)	p in C_p
g_{n}	(n=normal)	n in $\psi=\Sigma_n a_n \varphi_n$
m_{p}	(p=proton)	x in $\Sigma_x\, a_x\, b_x$
μ_{r}	(r=relative)	i,k in g_{ik}
Θ_{E}	(E=Einstein)	x in p_x
E_{k}	(k=kinetic)	
X_{e}	(e=electric)	

II. Symbols for Physical Quantities

Section 5: Electricity.

(a) *Definition of susceptibility.*

The electric and magnetic susceptibilities were defined originally in connection with nonrational three-dimensional systems of electric and magnetic quantities according to the formulae:

$$D=\epsilon_{\mathrm{r}}E=E+4\pi P \qquad B=\mu_{\mathrm{r}}H=H+4\pi M$$
$$P=\chi_{\mathrm{e}}E \qquad M=\chi_{\mathrm{m}}H$$
$$\chi_{\mathrm{e}}=(\epsilon_{\mathrm{r}}-1)/4\pi \qquad \chi_{\mathrm{m}}=(\mu_{\mathrm{r}}-1)/4\pi$$

The SUN Commission has considered the different possibilities to generalize these definitions to the case of a four-dimensional system of quantities. In agreement with most of the literature in this field the SUN Commission recommends that the appropriate definitions of the susceptibilities in the four-dimensional system should be *in the nonrational system of equations:*

$$_{\mathrm{n}}D={}_{\mathrm{n}}\epsilon E+4\pi P \qquad B={}_{\mathrm{n}}\mu({}_{\mathrm{n}}H+4\pi M)$$
$$P={}_{\mathrm{n}}\chi_{\mathrm{e}}\cdot{}_{\mathrm{n}}\epsilon E \qquad M={}_{\mathrm{n}}\chi_{\mathrm{m}}\cdot{}_{\mathrm{n}}H$$
$$_{\mathrm{n}}\chi_{\mathrm{e}}=(\epsilon_{\mathrm{r}}-1)/4\pi \qquad {}_{\mathrm{n}}\chi_{\mathrm{m}}=(\mu_{\mathrm{r}}-1)/4\pi$$

and in the rational system of equations:

$$_{\mathrm{r}}D={}_{\mathrm{r}}\epsilon E+P \qquad B={}_{\mathrm{r}}\mu({}_{\mathrm{r}}H+M)$$
$$P={}_{\mu}\chi_{\mathrm{e}}\cdot{}_{\mathrm{r}}\epsilon E \qquad M={}_{\mathrm{r}}\chi_{\mathrm{m}}\cdot{}_{\mathrm{r}}H$$
$$_{\mathrm{r}}\chi_{\mathrm{e}}=\epsilon_{\mathrm{r}}-1 \qquad {}_{\mathrm{r}}\chi_{\mathrm{m}}=\mu_{\mathrm{r}}-1$$

The relation between the nonrational and the rational concept of susceptibility is in both cases

$$_{\mathrm{r}}\chi=4\pi{}_{\mathrm{n}}\chi$$

(b) *Symbols for relative permeability and permittivity.*

The generally recommended symbols for relative permittivity and permeability are:

$$\epsilon_{\mathrm{r}}=\epsilon/\epsilon_0 \qquad \mu_{\mathrm{r}}=\mu/\mu_0$$

Against this notation serious objections can be made:

(1) It is difficult because the quantity ϵ_r or μ_r needs another index a ("anfang") or i ("initial") for ferromagnetic substances.

(2) It is strange to indicate a quantity of the type μ_r or ϵ_r, which is a dimensionless quantity of totally different type from μ or ϵ itself, with the same symbol. Also the International Electrotechnical Committee is considering the possibility of introducing instead of ϵ_r and μ_r different quantities, not having an index. It is the opinion of the SUN Commission that a reasonable choice might be the letters K instead of ϵ_r and k instead of μ_r, the first moreover being in agreement with the choice made by Maxwell. Also the name relative permeability could be replaced by the better name magnetic coefficient or constant, analogous to the name dielectric coefficient or constant, used in the electric case. The different quantities with their symbols would then be:

ϵ =permittivity

ϵ_0 =permittivity of vacuum

$K=\epsilon/\epsilon_0$=dielectric coefficient or constant

μ=permeability

μ_0=permeability of vacuum

$k=\mu/\mu_0$=magnetic coefficient or constant.

It is not intended at present to make a definite proposal of this, but rather to solicit the reactions on this of the national committees.

(c) *Symbols for electromagnetic moment and magnetic dipole moment.*

The present situation with respect to the symbols for the electric and magnetic dipole moments is as follows:

(1) Dielectric polarization:	$D=\epsilon_0 E+P$: P
Electric dipole moment (dimension: P/n):	p
(2) Magnetization:	$B=\mu_0(H+M)$: M
Electromagnetic moment (dimension: M/n):	$\boldsymbol{\mu}$
(3) Magnetic polarization:	$B=\mu_0 H+\mu_0 M$: no symbol for $\mu_0 M$
Magnetic dipole moment (dimension: $\mu_0 M/n$):	m

The concepts (2) based on the $B-E$ analogy are in general use in physics. The concept (3) will only be needed when one bases magnetism on the $H-E$ analogy. Therefore the SUN Committee has not given any particular recommendation for $\mu_0 \boldsymbol{M}$ although the IEC recommends $\boldsymbol{J}$ for it. It is regrettable, however, that the symbol $\boldsymbol{m}$ has now been recommended for magnetic dipole moment, because it would have been more symmetrical if $\boldsymbol{M}$, $\boldsymbol{m}$ and $\boldsymbol{\mu}$ would all belong together just as $\boldsymbol{P}$ and $\boldsymbol{p}$ in the electrical case.

A possibility would be to recommend to change our previous recommendation and to recommend *both* the symbols $\boldsymbol{m}$ and $\boldsymbol{\mu}$ ($\boldsymbol{\mu}$ is *very* much used for nuclear moment, electromagnetic moment, etc.) for electromagnetic moment. One could then use instead of $\boldsymbol{m}$ either $\boldsymbol{p}$ or $\boldsymbol{j}$ for the magnetic dipole moment or simply state that no symbol for $\mu_0 \boldsymbol{m}$ is recommended. The SUN Commission would be interested to know the opinion of the national committee in this matter.

III. Mathematical Operations and Symbols

(a) *The use of the solidus in mathematical equations and in numbers.*

In *expressions containing products* like $a \cdot b + c$ there is no doubt that this means $(a \cdot b) + c$ or $ab + c$. But when in *expressions with fractions* the solidus is used instead of the horizontal bar, considerable confusion can result from inaccurate notation, e.g., sometimes $a/b+c$ is written for $a/(b+c)$, etc. The SUN Committee therefore makes the following:

Proposal 5a: The solidus may be used in a fraction to separate the numerator from the denominator. When there is any doubt where the numerator ends or where the denominator starts, brackets should be used. *Examples:*

Expressions with a horizontal bar:

$$\frac{a}{bcd} \qquad \frac{a}{b \cdot c \cdot d}$$

$$\frac{2}{9}\sin kx \qquad \frac{1}{2}RT$$

$$\frac{a}{b} - c$$

$$\frac{a}{b-c}$$

$$\frac{a-b}{c-d}$$

$$\frac{a}{c} - \frac{b}{d}$$

How these should be written using the solidus:

$$a/bcd \qquad a/b \cdot c \cdot d$$

$$(2/9)\sin kx \qquad (1/2)RT \text{ or } RT/2$$

$$a/b - c$$

$$a/(b-c)$$

$$(a-b)/(c-d)$$

$$a/c - b/d$$

Proposal 5b: It is recommended that in expressions like

$$\sin[2\pi(x-x_0)/\lambda], \quad \exp[(r-r_0)/\sigma]$$

$$\exp[-V(r)/kT], \quad \sqrt{(\epsilon/c^2)}$$

the argument should always be placed between brackets, where this consists of a product or quotient of quantities. Exceptions are the cases in which the argument is a simple product of two quantities:

$$\sin kx \quad \exp -\alpha r \quad \exp -\alpha V$$

When the horizontal bar above the square root is used, no brackets are needed.

(b) *Use of solidus in unit expressions.*

Considerable confusion results from the inaccurate use of more than one solidus in unit expressions. The SUN Committee therefore recommends:

Proposal 6: In expressions for units not more than one solidus should be used. *Examples:*

Not: cm/s/s,	*but*: cm/s^2 = cm s^{-2}
Not: neutrons/cm/sterad,	*but*: neutrons/cm sterad = neutrons cm^{-1} sterad^{-1}
Not: 1 poise = 1g/s/cm,	*but*: 1 poise = 1 g/s cm = 1 g s^{-1} cm^{-1}
Not: J/°K/mole,	*but*: J/°K mole = J °K^{-1} mole^{-1}

IV. Units

(a) *Definition of the mole.*

A detailed discussion has taken place in the SUN Commission about the concept of gram molecule or mole which is sometimes considered as a noncoherent unit of mass, which varies from substance to substance, but which on the other hand is very often considered as an independent basic unit, used in statistical mechanics as a unit for "quantity of substance." The committee felt that this last definition should be considered in physics as the most appropriate definition of the mole.

As an appropriate symbol for "quantity of substance" the SUN Committee considered the symbol Q and the unit should thus be written as *mole*.

The *grammole* should then be considered as noncoherent mass-unit according to the first concept. The conclusions may be summarized in the following recommendation:

Proposal 7: (1) It is recommended that the unit "mole" should be considered in physics as a unit for *quantity of substance* (indicated by the symbol Q). Its definition should be: 1 mole (symbol: mole) is the quantity of substance which contains the same number of molecules (or ions, or atoms, or electrons, as the case may be) as there are atoms in exactly 16 gram of pure oxygen isotope ^{16}O. This quantity and the corresponding unit should be considered in the field where they are used as a fundamental (or basic) quantity and unit respectively.

(2) Related quantities, defined in terms of this quantity are:

(a) The molar mass (Definition: $M=m/Q$, m = mass of quantity of substance Q) with CGS unit: g/mole.

(b) The molar volume (Definition: v/Q, v = volume of quantity of substance Q) with the CGS unit: cm^3/mole.

(c) The "molecular weight" with the definition:

$$\text{molecular weight}=\frac{16\times\text{molar mass of substance}}{\text{molar mass of (atomic) }^{16}\text{O}}$$

which quantity thus should be considered as a pure number.

(d) *Avogadro's constant* (Definition: N/Q, N is number of molecules in a quantity of molecules in a quantity of substance Q) with the unit: mole^{-1}. Its present value should thus be expressed as: $N_0=N/Q=6.025\times10^{23}\ \text{mole}^{-1}$.

(3) *Remark:* The unit "grammole" (symbol: g mole) should be considered as a noncoherent unit of mass characteristic for any particular substance.

(b) *Use of double prefixes.*

Attention should be drawn to the fact that double prefixes are used in cases where single prefixes are available and recommended by the decisions of several international bodies. It is therefore proposed to make the following recommendation:

Proposal 8: The use of double prefixes should be avoided whenever single prefixes are available, e.g.

Not: mμs, *but:* ns (nano second)
Not: kMW, *but:* GW (giga watt)
Not: μμF, *but:* pF (pico farad)

(c) *Use of brackets in unit expressions.*

It is sometimes argued that when a prefix is added to a unit, e.g., cm, mA, and the unit is squared, brackets would be necessary. The SUN Committee considers this to be superfluous and recommends to accept the following:

Proposal 9: When a prefix is placed before the symbol for a unit, the combination of prefix and symbol should be considered as *one new unit symbol* which can be squared or cubed without using brackets. *Examples:*

$$cm^2,\quad mA^2,\quad \mu s^2$$

Remark:

A prefix should never be used before a unit which is squared. *Example:*

cm^2 *means always* $(0.01\ m)^2$
and never $0.01\ m^2$

(d) *The unit symbol for kilogramforce.*

At the General Assembly of the International Standardizing Organization Technical Committee 12, in 1955, in Copenhagen, a discussion took place on the possibility of recommending one internationally recommended symbol for the unit kilogramforce of the metric technical system. Many different symbols, kg, kg*, kgf, kp, are in use.

The conclusion was that very many countries were willing to consider seriously the possibility of switching over to the symbol kgf (kilogramforce) in case that a unanimous agreement on this symbol could be obtained from all countries. This symbol could be used in the French and English language and in fact England, the USA, the USSR and most countries of Europe were in favor of this proposal.

Unfortunately, however, Austria, Germany, and Sweden strongly object to this symbol because the symbol kp (kilopfund) has been adopted in these countries.

The SUN Committee has discussed this situation and considered the possibility of using an entirely new symbol and name for the units kilogramforce and gramforce:

kf (kilofors)
f (fors)

The word fors is a Latin word for force, one fors being defined as the force which is exerted by the standard gravity field on a mass of one gram.

It is not intended to make any definite proposal in this connection, but the SUN Committee is interested in the reactions of the national committees on this suggestion.