

Notes on the Writing of Scientific English for Japanese Physicists

Anthony J. LEGGETT

Introduction

These notes are emphatically not intended as a comprehensive guide to the writing of scientific English; I am sure there already exist many good books devoted to this purpose. However, during my work over the past year correcting the English of papers submitted to 'Progress' I noticed that certain patterns of mistake turned up over again; many of these, it seemed, could be avoided by the use of a fairly simple rule. These notes, therefore, are simply an attempt to eliminate some of the more common errors and sources of obscurity which sometimes make 'Japanese English' difficult to read.

The main guiding principles I have used are the following. First, it is much more important that the English written by Japanese authors be clear and easily readable than that it be elegant. Therefore, in a situation where there is a choice between an elegant form of expression which, however, may easily lead to confusion if misused and a less elegant but practically 'foolproof' one, I have never hesitated to recommend the latter. Secondly, the importance of avoiding a mistake is roughly proportional to the amount of misunderstanding it may entail and/or the amount of psychological 'wear and tear' it may cause on the reader's nerves. Accordingly, I have spent a good deal of space on 'macroscopic' points like sentence

construction, and proportionately less on 'microscopic' ones like the correct use of 'a' and 'the'; prepositions, which most Japanese writers seem to consider a major point of difficulty in writing English, I have scarcely mentioned, not only because this is the sort of point for which one can easily refer to dictionaries but because I believe the reader can usually correct any mistake for himself with very little mental effort. Thirdly, the usefulness of a set of notes such as this is much reduced if the rules given become too complicated. Therefore, rather than give a complicated set of rules which would ensure correctness 100% of the time, I have often preferred to give a simple rule which will be right 95% of the time, provided that in the other 5% of cases it is unlikely to lead to confusion. I do not claim that anyone who tries to follow the advice given here will write beautiful or even invariably correct English; but I hope that what he writes will be clear and readable and that any mistakes he does make will be minor ones.

The order in which the subject-matter is arranged is, roughly speaking, from 'macroscopic' to 'microscopic'; consequently, the points covered in the earlier sections are of more fundamental importance but the advice given is necessarily somewhat general and vague, while the latter sections cover more

detailed points where fairly precise rules can usually be given. I hope any notation used will be self-explanatory (' $A \rightarrow B$ ' means A is incorrect and B is the correct replacement). Most of the sentences quoted as examples of typical errors are either entirely my own invention or are substantially changed from their original forms; it is not claimed that they necessarily make sense as physics.

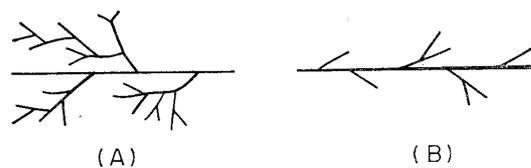
I should like to express my gratitude to Dr. K. Nishikawa, who generously devoted a good deal of time to constructive criticism of these notes. The responsibility for the opinions expressed remains of course entirely my own.

§ 1 General

At first sight, it is tempting to think that the problem of writing good English is solved if one can write good Japanese and then give a perfect translation. I believe this is not necessarily true. 'Japanese English'* has the peculiar property that it can be grammatically perfect and yet, if not completely unintelligible, at least 'opaque' and baffling to the average English reader. This property is often shared by English translations (even by expert translators) of articles written originally in Japanese; it is clearly, therefore, not due to bad translation. I believe, therefore, it is necessary to recognize that some *patterns of thought* which are acceptable in Japanese may be unintelligible or puzzling in English (and, no doubt, vice versa). Moreover, ways of saying things which make sense against a Japanese background may either be nonsense or give quite the wrong impression when interpreted against a Western European one. (For instance, if you state a conclusion tentatively or indefinitely, a Japanese reader will understand that this is because you do not wish to be too blunt or assertive, but a European reader will often conclude simply that you are not really sure about it). Since, presum-

ably, the vast majority of your readers will share the Western European background, it is necessary to make allowance for this fact. Of course, this problem is less important in scientific writing than in some other kinds, and the vast majority of Japanese physicists obviously recognize and make allowances for it; however, when it is not recognized the resulting confusion is so deep-seated that it is worth emphasizing in some detail. Here are some ways in which I believe acceptable modes of expression may differ in English and in Japanese.

1) In Japanese it seems that it is often legitimate to state a number of thoughts in such a way that the connection between them, or the meaning of any given one, only becomes clear when one has read the whole paragraph or even the whole paper. This is not so in English; each sentence should be completely intelligible in the light only of what has *already* been written. Moreover, the connection between one thought and the next should be completely clear when it is read; for instance, if you deviate from the 'main line' of the thought to explore a side-track, this should be made clear at the point where the side-track *starts*, not where it finishes. Perhaps this is best illustrated by the following diagram, where the 'direction of reading' is from left to right:



To an English reader, the Japanese pattern often seems to be like (A), whereas only (B) is usually allowable in English. Notice also that the tree in (B) has only a few branches; in English it is usually not a good thing to wander too far off the 'main track'.*

2) In English the sequence of thought should always be made quite explicit, even

* Hereafter abbreviated J. E.

* If you want to make a lengthy excursion, it is often better to do so in a footnote.

when, in Japanese, it would be legitimate to leave the reader to fill in the connection for himself. A common vice of J. E. is the writing of sentences like 'It is uncertain whether this resonance should be assigned to the (56) or (82) representation, though Jones has suggested that its spin is $1/2$ ' (where the reader is left to fill in 'which, if true, would force us to assign it to the (56) representation'). Of course, to some extent what you may safely leave out depends on the degree of background knowledge you are presuming in the reader, but it is much better to be over-explicit than not explicit enough. Western readers sometimes compare J. E. to a classical Japanese painting; the reader has to fill in most of the picture for himself. If he is used to doing this, of course, it presents no great difficulty, but most English readers are not and the effect is merely bewilderment.

3) In English it is essential to be precise and unambiguous. You may sometimes feel that it is advantageous to leave a certain amount of ambiguity in a statement, —a certain amount of 'room for manoeuvre' as it were; but this is never allowable in English. Ask yourself continually 'what *exactly* does this sentence mean?' If you can't answer this question, it is usually best to leave the sentence out altogether. Similarly, when you write an 'it' (or 'which,' or 'this,' etc.) always ask yourself 'what?' An 'it' in English should always refer to something definite,* and moreover something which has already been mentioned in the text (it may of course be something quite complicated, like 'the fact that....' — in this case the word 'fact' itself of course need not have occurred). Too many Japanese writers appear to use 'it' to refer to something which they have in their minds and they expect the reader to have in his!

4) Japanese seems to have a strong tendency to avoid too definite or assertive

* Except of course in certain special grammatical constructions, such as 'it is clear that...'

a statement, possibly because it is thought presumptuous to impose one's own views on the reader without conceding that there are possible alternatives. This notion is completely foreign to most Western readers, and they will usually be unable to make the 'mental jump' necessary to appreciate it; if you state your opinion vaguely because you want to leave room for various possible interpretations besides your own, they will often simply take this as a sign of vague and muddled thinking. Therefore, try to be as definite and assertive as possible, even if it feels a little unnatural. If you have definite, concrete reservations about your views, or conclusions, then state them explicitly (in a footnote if necessary); if not, then don't try to soften the force of your assertion at all. In particular, it is almost hopeless to try to translate phrases like "であろう", "と書いてよいのではないかと思われる", "と見てもよい" etc. into English (see also section 6); if you find you have to think out your sentence in Japanese and then translate it (a process which is of course not to be recommended but may be unavoidable for many people) then before translating change the first to *である* and leave out the second and third altogether.

5) To an English reader, Japanese (and J.E.) often seems vague and diffuse—there seem to be many clauses or sentences which add nothing substantial to the meaning. In English, on the contrary, every clause should 'pull its weight'. In particular, it is a very bad habit to imply vaguely that there is something more to be said unless you intend to say it explicitly. Thus, sentences like the following should usually be avoided:*

'This may give a very definite picture.'
'This may be viewed from the stand-

* The isolated examples given here are in fact unlikely to lead to very serious confusion. To give an example of a sentence of this type which could completely baffle the reader would require writing out the whole context.

point of various considerations.'

'It will be essential to study the problem from this point of view.'

'This is useful not only for...but also for examination of the effect from various sides.'

Such sentences are quite legitimate if they introduce an explicit discussion; for instance, the first is all right if you go on to describe the 'definite picture' or the second if you go on to enumerate the 'various considerations'. However, it is definitely a sign of bad writing in English to use them in isolation as a *substitute* for an explicit discussion. If this were merely a matter of good style one might afford to neglect it without serious confusion; however, I believe it is just such sentences which make a major contribution to the peculiar 'opaqueness' of some J.E.. The point is that the English reader is not usually expecting such sentences in isolation, and therefore if you make 'microscopic' (grammatical and other) mistakes in it he will often be unable to guess the intended meaning from the context. Therefore, if you don't want to state an idea or set of ideas explicitly, don't refer to them at all.

To summarize: make sure that your argument runs as a logical *sequence* and that no essential steps are left unwritten, be as precise, unambiguous and explicit as you can, and don't hesitate to state your conclusions boldly and definitely. Once this is done the problem of writing good English is indeed largely reduced to the problem of good translation.

§ 2 Sentence Construction

Write short sentences.

This may seem unnecessary advice since random sampling shows that the average sentence in 'Progress' is already a good deal shorter than that in 'Phys. Rev.'; you may in fact sometimes hear Westerners criticize J.E. on the grounds that the sentences are too short and it reads jerkily. To some

extent this is true, but this is a small defect and it is very much less wearing on the nerves to read a succession of short sentences, with the connection between each properly indicated, than to have to try to sort out a long and ill-constructed one.* The shorter the sentence, the less the chances of serious ambiguity. So, if your sentence is more than 40 words long, you should think seriously whether you cannot break it up with at least a semi-colon (see below); as to the *average* length of a sentence,** 20 words is a good average to aim at and even 15 is probably not too short. Remember in any case that the English sentence is a system of strictly limited *capacity*; it can tolerate only a few subsidiary clauses and these must all be fitted tightly into the sentence structure. *There is no analogue of the Japanese 'suspensive' construction in English.* The following points should be given special attention:

a) If you have an important idea to express, don't put it in a subsidiary clause. Instead, start a new sentence. For example, consider the following sentence:

'Compared with the Nagoya model, these newer models seem to be rather more plausible in explaining the mechanism binding the baryons and leptons, by introducing a third quantum number besides the usual isotopic spin and hypercharge and by considering the existing baryons and bosons to represent a neutral state of this quantum number, although they must generally produce many particles so far undiscovered, as a result of the increased number of elements and the reduced symmetry.'

This sentence (76 words) is much too long

* To some extent jerkiness can be avoided by replacing some of the full stops with semi-colons (see below).

** That is, (number of words)/(number of periods plus semi-colons).

on general grounds. In addition there are presumably three different important ideas in it: 1) The newer models are better than the Nagoya model in explaining the binding mechanism. 2) The origin of this superiority is the introduction of a third quantum number, etc.. 3) Nevertheless they predict many particles so far undiscovered. Each of these ideas deserves a sentence, or at least a main verb, to itself. Thus,

‘Compared....leptons. This is because they introduce....number. However, they must....symmetry.’

This point applies particularly to sentences containing a long relative clause as the final part. For instance, consider:

‘From eq. (3.10) we get the final result that the inelastic shadow scattering must dominate the cross-section above a few tens of BeV, if we assume $SU(6)$ symmetry and take the parameter λ to have a reasonably small value, which is in strong disagreement with the experimental results unless we assume a very peculiar form for the function $f(S)$, as was shown by Brown from considerations of crossing symmetry.’

Again this sentence is too long, and in addition the fact that the result is in disagreement with experiment is an important new point. Thus,

‘From....value. This result is....symmetry.’

(Another good reason for breaking up the sentence in this way is that as it stands it is not clear what the ‘which’ refers to—see also below (section 3)).

b) Don’t suspend a subordinate clause or phrase at the end of a sentence when it is not perfectly clear what it refers to. Be especially careful with clauses beginning

with ‘as’ ‘similarly to’ or ‘by (in)....-ing.’ A very common and misleading type of case is the following:

‘We find that the function $F(x)$ has an infinite range but the magnetization below T_c does not tend to a finite value, as was suggested by Brown.’

From this sentence as it stands the reader who is unfamiliar with Brown’s work may draw any one of three conclusions about his suggestion:

- 1) The function F has a finite range and the magnetization does not tend to a finite value.
- 2) The magnetization does not tend to a finite value (no conclusion about F)
- 3) The magnetization tends to a finite value.

It is easy to remove the ambiguity by breaking the sentence up into two, either by a full stop or by a semi-colon (see below). According as the meaning is 1), 2) or 3) we should write:

- 1) ‘We find....value. These results agree with the suggestion of Brown.’
- 2) ‘We find....value. This second result agrees with....’
- 3) ‘We find....value. This second result conflicts with....’

This is not necessarily always the most natural way of removing the ambiguity but it is by far the safest. Compare also the sentence:

‘This feature seems to be disadvantageous to the collective nature of the excitation....especially in bringing about a large transition probability.’

As it stands it is not clear whether this means that the feature in question does or does not bring about a large transition probability (though I think most readers would assume that it *does*). Again, a straightforward way of removing the ambiguity is to

start a new sentence: 'In particular, it brings about....' or 'In particular, it cannot bring about....'

In short, whenever you are tempted to write a subsidiary clause after the main one, ask yourself whether it wouldn't be better to start a new sentence. This may sometimes be the less elegant alternative but, provided it is grammatically possible, it is rarely wrong and the gain in intelligibility usually amply compensates for the loss in elegance!

Use of the semi-colon.

Too many Japanese authors (like many English ones, unfortunately) seem unaware of the existence of this punctuation mark (;). Roughly speaking, it is used to break up a long sentence when the ideas are too closely connected to be put in separate sentences; it indicates a break in the thought considerably stronger than that implied by a comma but weaker than that implied by a full stop (period). For grammatical purposes it is equivalent to a full stop. Thus, consider the sentence.

'High energy scattering above a few GeV is investigated as the shadow scattering of multiple production, for which phenomenological, peripheral and uncorrelated jet models are used.'

In this sentence the clause beginning 'for which' is important enough to stand by itself, but since it is so short and so closely connected with the rest of the sentence a full stop would give an unnecessarily jerky effect. Thus, use a semi-colon:

'High energy....production; phenomenological....used.'

In many other cases, when you are tempted to start the second part of a sentence with '...., which....' or '...., and it....'

it is much better to put a semi-colon: '....; this (result)....' etc.. In most cases it is largely a matter of taste whether to use a semi-colon or a full stop. (But remember that it is unusual for a sentence to contain more than one semi-colon.) However, ample use of the semi-colon will help to avoid over-clumsy sentences while giving a less jerky effect than a sequence of completely detached sentences.

Keep qualifying phrases and clauses to what they qualify.

Consider the sentence:

'We investigate the scattering of pions by protons at a few MeV, paying special attention to the problem of the imaginary part of the phase shifts, which was previously discussed by Jones, who assumed a hard-sphere potential, in the SU_3 model.'

As it stands it is not clear whether 'in the SU_3 model' refers to 'discussed by Jones' or to 'we investigate.' In either case it should follow the verb directly 'discussed in the SU_3 model' or 'we investigate, in the SU_3 model,....' (Actually this sentence would in any case better be broken up, with a semi-colon after 'shifts'.)

Similarly consider:

'The theory can explain the magnetic moments of the baryons, the approximate $SU(6)$ symmetry scheme satisfied by all lowlying resonances and the fact that the scattering amplitudes appear to be well predicted by the Smith formula in a unified way.'

Here it looks as if 'in a unified way' qualifies 'predicted' whereas it presumably is actually meant to refer to 'explain.' Thus we should write 'The theory can explain in a unified way the magnetic moments.... Smith formula.' Try to avoid qualifying a

word by more than one phrase or clause; if this is unavoidable it is generally better to put the shorter and less important one first. Thus, e.g. 'We can carry out the integration in a straightforward way by making the substitution $x = y^2$ and transforming to polar coordinates' (not 'we can... integration by making... coordinates in a straightforward way'). Above all, make sure that qualifying clauses and phrases qualify something which is actually *in the sentence*, not something in your mind. Typical of a common fault in J.E. is the sentence 'The proton and neutron masses are different by considering the effect of the pion cloud.' 'By considering' here is obviously meant to qualify some unwritten verb like 'understand' or 'explain', but this is not allowable in English, so we must write, e.g. 'We can understand (explain) the fact that the proton and neutron masses are different by considering....' (or, of course, 'the proton...are different *because of* the effect....') This particular example is fairly easy to disentangle, but I have read many similar ones where this mistake could make the sentence quite unintelligible.

In short: remember that in English every subsidiary clause and phrase must have a definite place in the sentence structure, and that as far as possible this place should be clearly indicated by the sentence order. Don't hang subsidiary clauses on to the end of a sentence if you are not sure just where they fit in—start a new sentence instead.

§ 3 Relative Clauses (... 'which....', 'who....', etc.)

English distinguishes quite sharply between two types of relative clauses (as far as I know, Japanese does not make this distinction explicitly): those which *identify* and those which *describe* or state a further fact about the subject of the clause. In the second type a comma is put before the 'which', in the first it is omitted. Thus, distinguish the two sentences:

a) 'We find the solution of eqs. (8-10)

which remains finite as $x \rightarrow 0$.'

b) 'We find the solution of eqs. (8-10),
which remains finite as $x \rightarrow 0$.'

Sentence (a) implies that there are (or at least may be) other solutions which do not remain finite; it *identifies* the solution which we find. Sentence (b) on the other hand implies that the solution is unique (otherwise the 'the' would be replaced by 'a' (see section 9)) and, further, states that it remains finite. In this case and in many similar ones we could rewrite (b) as:

'We find the solution of eqs. (8-10); this remains finite as $x \rightarrow 0$.'

In fact it is probably better to rewrite it this way whenever it is grammatically possible. But, in any case, remember that the insertion or omission of a comma can change the meaning entirely.

Generally speaking, a relative pronoun (in either of the senses a) or b)) should immediately follow the noun to which it refers. (This is always true for type-b sentences) 'Some solutions were obtained by Jones which satisfy (3.9.)' is best avoided;* and 'the pion parity which is emitted in the reaction' is *never* allowable (it is the pion which is emitted, not the parity). A common case in which this rule does not apply is when the noun is qualified by some other phrase as well as by the relative clause: e.g.

'the solution of eqs. (8-10) which remains finite' [type (a)],

'the solution found by Smith, which remains finite' [type (b)].

Be very careful to avoid ambiguity, however, in this kind of sentence; in the above examples both grammar and sense tells us that 'which' must refer to 'solution' and not to 'eqs. (8-10)' or to 'Smith', but in other cases it may not be obvious. Consider for instance:

* This construction is sometimes legitimate but it is difficult to give a general rule.

'Let us consider the solutions of the equations which were found by Jones' [type (a)]

'One then gets periodic solutions to the dynamical equations, which agree with those found by Jones' [type (b)].

Did Jones find the equations or the solutions? A reader with a detailed background knowledge of the subject may know, but you should never take such background knowledge for granted if you can possibly avoid it by rewriting the sentence in an unambiguous form. In a type-b sentence this is very easily done by starting a new sentence after 'equations': '....equations; these equations agree..' or '....equations; these solutions agree....' as the case may be. Case (a) is rather more difficult; a somewhat inelegant but foolproof way of removing the ambiguity is to replace the 'the' in front of the noun to which the 'which' refers by 'those':

'Let us consider those solutions of the equations which were found by Jones'

or

'Let us consider the solutions of those equations which were found by Jones.'

Again, the sentence

'We consider the irreducible subspaces of the space to which P and Q belong'

may be ambiguous under certain circumstances; it can be made unambiguous by rewriting it, according to the meaning, either as

'We consider those irreducible subspaces of the space to which P and Q belong'

or as

'We consider the irreducible subspaces of that space to which P and Q belong.'

If you do not do this, then generally speaking an English reader will tend to take the

'which' as referring to the last noun to which grammar and sense permits it to refer (that is, to 'equations' and 'space' in the examples given above). Remember that the use of 'that' and 'those' in conjunction with 'which' is confined to type-a relative clauses.

Make sure 'which' actually refers to something.

A type-b relative clause occasionally appears not to refer to any noun which actually appears in the sentence, as in:

'This argument predicts that the spin of U is $3/2$, which is in contradiction with experiment.'

Here the 'which' actually refers to '[the prediction] that the spin is $3/2$ '. However, this kind of usage is full of pitfalls and I would therefore advise Japanese writers not to use it if they can possibly avoid it; one of the most widespread vices of J.E. is the writing of relative clauses which apparently do not refer to anything. It is almost always possible to avoid this by beginning a new sentence and referring to the noun explicitly: e.g.

'This argument predicts that the spin of U is $3/2$; this *prediction* is in contradiction with experiment.'

(The same warning, incidentally, applies equally to 'this' and 'it'—see section 1)

§ 4 'Any' and 'All' especially in Negative Sentences

Consider the following two cases:

- (a) $\alpha_1 \neq 0, \alpha_2 \neq 0, \alpha_3 \neq 0, \alpha_4 \neq 0$
 (b) $\alpha_1 \neq 0, \alpha_2 \neq 0, \alpha_3 = 0, \alpha_4 = 0$

We can describe each of these cases in a number of ways: ((3)-(5) would of course be correct only in an appropriate context)

(a)

- 1) 'All of the α 's are different from zero.'

- 2) 'None of the α 's are equal to zero.'
- 3) 'We have set all of the α 's different from zero.'
- 4) 'We have set none of the α 's equal to zero.'
- 5) 'We have not set any of the α 's equal to zero.'

(b)

- 1) 'Some of the α 's are different from zero.'
- 2) 'Not all of the α 's are equal to zero.'
- 3) 'We have set some of the α 's different from zero.'
- 4) 'We have not set all of the α 's equal to zero.'

However, We can *never* say*

'Any of the α 's are not equal to zero'

or

'All of the α 's are not equal to zero'

It is best to use the rule that 'any' can never directly precede a negative, though it can follow it (as in (5a)). If you are tempted to write, e.g., 'Any mesons are not stable,' think carefully whether you mean 'No mesons are stable' (= 'all mesons are unstable') or 'Not all mesons are stable' (= 'some mesons are unstable'). In my experience, Japanese writers who write 'any...are not' usually mean 'none...are'; on this assumption the following replacements should be made:

'Any problems...do not occur' → 'no problems...occur'

'Anything...cannot be done' → 'nothing...can be done'

(or { 'We can do nothing'
'We cannot do anything' })

'Anyone...has not proved' → 'no-one has proved.'

'This series does not ever converge' is not actually wrong, since the 'ever' (which is analogous to 'any') follows the negative, but

* 'All...are not' occurs occasionally in spoken English in sense (b). However, it is practically unknown in written English.

'This series never converges' is much more natural. On the whole it is better to replace 'not...any' by 'none' or 'no' whenever you can;* thus 4a) is preferable to 5a) under most circumstances.

'Any' and 'all' in positive sentences.

The sentences

- a) 'All higher-order terms may be neglected' and
- b) 'Any higher-order terms may be neglected'

have a similar but not identical meaning. a) Implies that higher-order terms certainly exist; b) makes no such implication, but simply says that if they do exist, they may be neglected. 'Any' is especially common before a relative clause, e.g.:

'Any interaction which breaks the symmetry will change the results'

The rule about 'any' not preceding a negative does not apply, of course, if the negative is in the relative clause; thus the above example could be rewritten.

'Any interaction which does not conserve the symmetry will change the results.'

§ 5 'Only', 'Mainly', 'Not Only'

The positioning of 'only' is very important.** Contrast the three sentences:

- 1) 'Only the spin-orbit interactions renormalize the lifetime' (i.e. other interactions do not renormalize it).
- 2) 'The spin-orbit interactions only renormalize the lifetime' (i.e. they have no other effect).

* In this respect usage is different in spoken and written English.

** Here I discuss only the adverbial use of 'only'. The adjectival use does not usually give trouble.

- 3) 'The spin-orbit interactions renormalize only the lifetime' (i.e. they do not renormalize anything else).

It is best to try always to put 'only' immediately before the word which it qualifies. Thus, if $f(x, y) = x^2 + y^2$, $g(x, y) = y^2$, write 'only f is a function of x ' while if $f(x, y) = x^2$, write ' f is a function only of x '. Avoid ' f is only a function of x ' or ' f only is a function of x ' which are often ambiguous. If in doubt, it is often possible to rewrite the sentence to make the point quite clear: e.g. we could rewrite 1), 2) and 3) above respectively as

- 1) 'It is only the spin-orbit interactions which renormalize the lifetime.'
- 2) 'The only effect of the spin-orbit interactions is to renormalize the lifetime.'
- 3) 'The only thing renormalized by the spin-orbit interactions is the lifetime.'

Very similar remarks apply to 'mainly' (or 'chiefly' 'principally' etc.) In sentences 2) and 3) 'only' could be replaced by 'mainly' with the analogous meaning in each case. In sentence 1) this is also grammatically possible but for some reason it sounds rather odd and 1) would usually be rewritten 'It is mainly the spin-orbit interactions which....'

'Not only': Like 'only', this refers to the word which it directly precedes. Thus, e.g..

- 'Not only x but [also] y is divergent.'
 ' x is not only divergent but [also] meaningless.'
 ' x not only diverges but [also] contains a factor T^{-1} .'

If the 'not only' refers to the whole clause it is usually necessary to invert the order, e.g..

- 'Not only does x diverge but x contains a factor T^{-1} .'

(However, 'not only x diverges', though in-

correct, is unlikely in practice to lead to serious misunderstanding.)

Finally (a somewhat disconnected point): 'We have introduced only one free parameter' but ' x is introduced as *the only* free parameter' (not 'only one'). Also note 'The only free parameters are x and y ' (not 'The free parameters are only x and y ').

§ 6 'May be'/'Can be'/'Is'

'May be' is *not* the equivalent of 'であらう', which indeed is practically untranslatable into English (cf. section 1). The sentence ' y may be a function of x ' implies that you (the writer) *don't know* whether y is a function of x or not; if you use 'may be' merely because you think ' y is a function of x ' sounds too blunt, the average English reader will be completely baffled. 'May' in English has two main uses: 1) to indicate uncertainly, e.g. 'this series may not converge' 'the experimental data may be erroneous' 2) to indicate permissibility (in this sense it is often replaceable by 'can'), e.g. 'We may approximate this term by....' 'this term may not be neglected'. 'May' is *never* used in English just to make a sentence sound more polite (the connection between politeness and vagueness is completely unknown in English); so, if your sentence does not fit either of the above cases, don't use it. If you feel you must find an equivalent for 'であらう' at all costs, probably the best is 'we may say that....'(sense (2) of 'may'); but it is much better to be blunt and have done with it (cf. section 1) ('we may say that y is a function of x ' sounds odd since this is presumably not a matter of opinion!). Note also that although 'it may be interesting/plausible/possible that....' is not wrong, it is more usual to replace the 'may be' by 'is'.

'It is shown (proved, demonstrated)' almost always refers to a definite occasion, very rarely to the fact that something can be proved, has been proved at some indefinite time in the past, or has been proved by the author but not published. Thus, 'It is (was, has been) shown in ref. (6) that Z_3 is finite' or 'It is

shown in the Appendix that....', but 'It can be shown that Z_3 is finite [but we shall not bother to do so here]'. If this remark precedes a proof, then use 'can be': e.g. 'It *can be* shown as follows that Z_3 is finite:....' Similarly 'The cross-section *can be* calculated as follows:....' Also note ' $f(x)$ *can be* rewritten in the form....' ('is rewritten' is sometimes allowable but 'can be' is hardly ever wrong.*)

'It is thought (believed) that....' almost always means 'it is thought by people (physicists) in general that....' not 'I believe that....'. Thus 'it is believed that the nucleus consists of protons and neutrons' but '*The present author believes* that this result is incorrect'. Similarly 'V is regarded as an effective field' means it is so regarded by physicists in general; if, on the contrary, this is a view which you are proposing, say 'V may be regarded as an effective field' (sense (2) of 'may').

Other common errors of this type:

- 'is noted' → 'is to be noted' or 'may be noted' or 'should be noted'
- 'is desired (that)....' → 'is to be desired' or 'is desirable'**
- 'is emphasized' → 'is to be emphasized' or 'should be emphasized'
- 'is hoped' → 'may be hoped' or 'is to be hoped'

With regard to the last, however, distinguish 'it is to be hoped that this question will be investigated' (= I hope someone else will investigate it) from 'it is hoped to investigate this question' (= I intend to investigate it myself).

§ 7 Qualified Adjectives etc.

If an adjective or participle is qualified by a phrase, it *must* immediately precede it.

* 'We rewrite $f(x)$ in the form....' is of course equally good.

** However, note 'it is desired to express y in terms of x ' (= we wish to express....)

Examples:

- 'inverse relation of eq. (7)' → 'relation inverse to eq. (7)'
- 'exchanged particles between them' → 'particles exchanged between them'
- 'isobaric state of the initial one' → 'state isobaric to the initial one'
- 'identical equations with (3.7)' → 'equations identical with (to) (3.7)'
- 'relative order of magnitude to' → 'order of magnitude relative to'
- 'an intermediate stage of the first two' → 'a stage intermediate between the first two'

Be specially careful not to write, e.g. 'their intermediate stage' instead of 'the stage intermediate between them.' or 'its identical equation' for 'an equation identical with it'. Always think twice before translating *その* by 'its' or 'their'. 'Its', 'their' etc. can replace only 'of it (them)' and even then the replacement is not always correct. In particular, if the 'of' is directly connected to an adjective or adverb, as in 'independent of' the replacement is never correct; thus, 'the independent solutions of the wave equation' can be replaced by 'its independent solutions', (or, though less naturally, 'the independent solutions of it'), but 'the solutions which are independent of x , cannot be replaced by 'its (i.e. x 's) independent solutions'—we must write 'the solutions independent of it'. When in doubt it is probably safer on average to write 'of it (them)'.

An even more misleading type of error is one like the following:

- 'this is a gauge-transformation invariant of the electron operators.'

Here 'of the electron operators' qualifies 'gauge-transformation'; we must therefore rewrite the clause

'this is an invariant with respect to gauge-transformation of the electron operators'.

§ 8 'A' vs 'The' vs Nothing

Probably this is one of the most difficult points in the whole of the English language for most foreigners (not only for Japanese!). Luckily it does not usually cause serious confusion if you get it wrong, so I only mention a few points.

'The' usually implies in some sense the uniqueness of the object you are talking about, while 'a' (or in the case of the plural, the absence of an article) implies its non-uniqueness. Thus,

'The solution of (3.9) is given by (3.10)' implies that this solution is unique, while 'A solution of (3.9) is given by (3.10)' implies at least that there may be other solutions. Compare the following pairs of sentences:

- { 'f(x) is an analytic function of x.'
- { 'f(x) is the function of x defined by (3.11).'
- { 'f(x) is a Bessel function' (there are many Bessel functions but only one Airy function.)
- { 'f(x) is the Airy function.'
- { 'Two components of the momentum commute with H' (assuming the system is three-dimensional).
- { 'The three components of the momentum commute with H.'
- { 'Very small values of t are unphysical'
- { 'The very small values of t given by eq. (6) are unphysical.'
- { 'We regard x and y as quantities independent of R.'
- { 'We regard x and y as the only unknown quantities in this equation.'

The fact that the noun in question is qualified by a type-a relative clause (section 3) does not necessarily imply that it must take 'the': e.g.

{ 'We must look for the metal which has the highest transition temperature.'

{ 'We must look for a metal which has a high transition temperature.'

'X theory' vs 'The X theory'. This is not an important point but a fairly definite rule can be given. If X is the *subject-matter* of the theory, then 'X theory': e.g. 'solid-state theory' 'electromagnetic theory' 'superconductivity theory'. When X describes the postulates or methods of the theory, or names its author(s), then 'the X theory': e.g. 'the quark theory' 'the BCS theory' 'the quantum theory of radiation'. Thus, Professor Yukawa formulated 'the meson theory [of nuclear forces]' but Schweber *et al.*'s book deals with 'meson theory'. Possibly in 1976 there will be 'quark theory' but at present there is only 'the quark theory'!

In general, however, I would advise authors not to worry overmuch about 'a' and 'the'; there are many other points which deserve more attention.

§ 9 Singular vs Plural

The following nouns are never or very rarely used in the plural.*

Nature, character, behaviour, notation, knowledge, information, (experimental) support, agreement,** emission, scattering, advice, encouragement.

In general abstract nouns describing a process or action are used in the singular unless you are referring to a number of different occasions on which the action took place. A very common example is 'discussion': thus,

'We give a discussion of this point in section 5' (*not* 'some discussions'),

but

'The discussions of this point given in refs. (7) and (8) are inadequate.'

(However, 'the discussion of this point given in ref. (7) is inadequate'.) It is also conven-

* On the rare occasions when they can be used in the plural, the singular is equally correct.

** In physics contexts, at least!

tional to thank one's colleagues for 'helpful discussions'.

'*Situation*' is used in the plural only when it refers to two or more distinct cases. Thus, 'This situation is to be expected' (*not* 'these situations') but 'There is a superficial resemblance between our case and that studied by Smith, but the two situations are really entirely different.'

'*Experiment*': one usually uses the singular if the sense is general, e.g. 'in agreement with experiment' 'according to experiment' 'conflicts with experiment' 'take the values of α from experiment'. However, 'the experiments of Jones' 'high-energy p - p scattering experiments'. (Distinguish, incidentally, 'experiments' from 'experimental data': One usually says, for instance, 'the experimental *data* are subject to a large error'.)

The following nouns are normally used in the plural when the sense is general; they are used in the singular only when you are referring to *one particular* property, etc:

Features, properties, aspects, characteristics, circumstances. Thus, e.g.: 'let us examine (the properties/some features/various aspects/the characteristics) of this problem.' 'In these circumstances....', but, e.g.: 'The solution (2.8) has the peculiar property/feature/characteristic of being invariant under the interchange of x and y .' 'A disturbing aspect of this situation is that....' 'The unfortunate circumstance that f diverges makes it impossible to....'

Notice in particular that one always says 'transformation properties' 'symmetry properties' but (usually), 'Hermitian property' (this is the property of being Hermitian, whereas 'transformation properties' does not simply mean the property of being transformed).

§ 10 Words to Avoid or Use with Care

'*Image*' is practically never used in scientific literature.* '*Concrete*' is much less

* Except of course in a technical sense, as in 'the image of the Fermi surface'.

common in English than 具体的 in Japanese; it is best to confine it to phrases like 'a concrete example' or 'we chose a concrete form for the potential'. 'This may give some very concrete images' is typical J. E.:* if you must say it at all (cf. section 1) say 'This may give a very definite (clear) picture'. '*Standpoint*' is also much less common in English than 立場 in Japanese; 'from the standpoint of' is often best replaced by 'in connection with [the fact that....]' or 'in the light of (the fact that)....' Much the same applies to '*viewpoint*'. The words *aspect*, *character*, *nature*, *characteristics*, *features*, *circumstances*, *situation* seem to be particularly troublesome for Japanese authors; I can only recommend you to study their use when you read English papers, or use a dictionary which gives a large number of examples. Here is an example of the correct use of each:

'This equation has a Markoffian character.'

'The true nature of
 { the forces binding the baryons }
 { the random-phase approximation }
 is still not well understood.'

'The solution (4.3) has a number of interesting features.'

'The principal characteristics of the solution are as follows.'

'Various aspects of this problem remain insufficiently explored.'

'In view of the circumstances mentioned above, experimental detection may prove difficult.'

'The situation here is entirely analogous to that encountered in p - p scattering.'

In certain cases two or three of these words may be interchangeable (cf. the example in section 9), but it is rash to assume that this is always so.

* 'Concrete image' = コンクリートで造った仏像.
 In this kind of case there is really no good translation of 具体的.

§ 11 Miscellaneous

Note the following pairs, which are often confused:

- { 'Ferromagnetism is usually *attributed* to the electron spins.'
- { 'The electron spins are usually *invoked* to explain ferromagnetism.'
- { 'The nucleus *consists of* protons and neutrons.'
- { 'Protons and neutrons *constitute* the nucleus.'
- If $f(x, y) = f(x)$, then
 - { '*f* is *independent of y*.'
 - { '[The value of] *y* is *irrelevant to f*.'

(unusual)
- If $f(x, y) = x^2 \exp -y^4$, then
 - { '*f* is *sensitive to the value of y*.'
 - { 'The value of *y* is *critical for f*.'

(unusual)

'Necessarily does not....' vs 'does not necessarily': 'CPT invariance does not necessarily imply *T* invariance' but 'If the mass of the fission fragments is greater than that of the parent nucleus, then fission necessarily does not occur' (=cannot occur). The second use is however rare and best avoided.

'Both' vs 'the two': 'Both' in English has the sense of 両方とも; thus 'both the renormalization constants are equal to unity' but 'the two renormalization constants cancel one another.' 'Both renormalization constants are equal' (i.e. to one another) → 'the two r. cs. are equal'.

'Quite' vs 'considerably': The meaning of these two words is often very similar but 'considerably' is usually used only when a comparison is stated or implied. Thus '*x* is considerably larger than *y*' '*x* is considerably reduced' but '*x* is quite large'. Actually 'quite' is a rather ambiguous* word and it is often safer to replace it by 'rather'.

* 'The effect is quite strongly suppressed' = 'suppressed to a large extent but not completely.' 'The effect is quite suppressed' = 'completely suppressed.'

Note the following expressions which are listed roughly in order of increasing strength:

- 'X is a little larger/somewhat larger/rather larger/considerably larger/a good deal larger/very much larger than Y.'
- 'X is fairly large/quite large/rather large/very large.'

(Actually in the second row 'fairly' 'quite' and 'rather' are almost indistinguishable.)

'Namely' vs 'that is': 'Namely' is used when you are about to name or identify something you have already described: e.g. 'Using the best available data, namely these of Brown...' or 'There is one difficulty. Namely, the integral in (3.1) does not converge.' 'That is' is used to introduce an explanation of something you have said, e.g. 'Region II, that is, the region in which the heavy mesons play a dominant role....' or 'The validity of this procedure is doubtful. That is, it is not clear that we can replace....' In my experience 'that is' is right 90% of the time, especially at the beginning of a sentence.

- 'will be able to be replaced' → 'can be replaced'
- 'may have a possibility to' → 'may be able to' or 'can'
- 'suggests us that' → /suggests that'
- 'formulae (expressions) for *f*' (not 'of *f*')
- 'conditions (restrictions) imposed on M by rotational invariance' (not 'to M')
- 'effect of the Coulomb terms on S' (not 'to S')
- 'X can be expressed (rewritten) in terms of Y' (not 'by Y')
- 'construct the wave function from Bloch waves' (not 'with')
- 'X is insensitive in comparison with Y' but 'X is less sensitive than Y'
- 'associate A with B' (not 'to')
- 'The concerned baryon' → 'The baryon concerned'
- \sum_p is 'a summation over *p*' (not 'of *p*')

'our interesting amplitude' → 'the amplitude of interest to us'

'We pick up the ring graphs' → 'pick out' or 'isolate' or 'select for special treatment'

'operating $\partial/\partial X_\mu$ on ψ ' → 'operating with $\partial/\partial X_\mu$ on ψ '

§ 12 Minor Stylistic Points

Try not to start sentences with 'and', 'but', 'so'.* Instead of 'and' use 'moreover' or 'further', instead of 'but' use 'however' or 'nevertheless'; instead of 'so' use 'therefore' or 'hence'. Don't end sentences with 'too' or 'however' (or indeed any conjunction), though 'however' is sometimes allowable at the end of a very short sentence.

Be careful about starting sentences with 'Then'. It is *not* legitimate to use this in the sense of 'therefore'. Japanese authors are probably confused by sequences like: 'Let us suppose the series converges. Then we can replace....' The 'then' here does *not* mean 'therefore'; the sense is 'when (or if) we have supposed the series to converge, then we can....' Although the use of 'then' for 'therefore' is not a serious mistake, it is very widespread and worth watching out for.

'Especially' usually qualifies an adjective or adverb ('It is especially important to....') not a whole clause. At the beginning of a sentence it should usually be replaced by 'In particular'.

'Somewhat' vs 'more or less': 'This is more or less established experimentally' means roughly 'The experimental evidence is not completely conclusive but it is very good.' 'More or less' is *not* the equivalent of 多少. 'Somewhat' is roughly equivalent to 'rather' or 'quite' (see section 11) (e.g. 'this is a somewhat doubtful procedure.')

'A few' vs 'several': 'A few' tends to emphasize the smallness of the number involved, while 'several' tends to emphasize its largeness. Thus, e.g. 'The strength of this

interaction cannot be more than a few keV' but 'Detection of this effect requires a field of several million oersteds'. When neither emphasis is needed 'a few' is usually used, e.g.: '*pp* scattering at a few BeV is investigated.'

'Based on'. This is an adjectival phrase and as such *must qualify a noun*. Sentences like 'Based on the Landau theory, the magnetic susceptibility is investigated' are very bad English;* we should write 'On the basis of the Landau theory, the m.s. is investigated'. However, 'we give a treatment based on the Landau theory' is correct, since 'based on' qualifies 'treatment'.

'We had better' sounds very colloquial: it is best replaced by 'it is best to....'

In the sentence 'X and Y are equal to each other' the 'to each other' can usually be left out without any danger of ambiguity.

Events 'take place' (or 'occur') but poles (of propagators etc.) 'occur' or 'appear' (not take place).

'The functions F_i 's' → 'the F_i 's' or, better, 'the functions F_i '.

'The Okubo-Marshak formula' but 'Okubo and Marshak have shown....' (never 'Okubo-Marshak have shown'.)

Of course a few Western names are actually hyphenated (Gell-Mann, Lennard-Jones, etc.)

あとがき

今回京都大学の小林稔先生から, Leggett 氏の "Notes on the Writing of Scientific English for Japanese Physicists" が送られて来ました。これは同氏がこの一年間京都大学に滞在中 Progress of Theoretical Physics の Language Consultant として英文の校訂をされた経験をもとに, 特に日本の物理学者を対象に書かれたものです。会誌編集委員会で協議したところ, これは会員が英語の論文を書くのにも, 関

* This is another point in which spoken and (scientific) written English differ.

* Despite the fact that they occasionally appear in Phys. Rev.!

読者が英文をなおすのにも非常に役立つと考え、これを掲載することにしました。

なお、Anthony James Leggett 氏について簡単に紹介します。1961年 Oxford 大学を卒業、64年 tel Haar 教授の指導のもとで学位をとり、Research Associate として、Illinois 大学に行き、64~65年の

間 Pines 教授のもとで超流動の研究をし、65年9月から、京都大学理学部物理学教室松原研究室に客員研究者として滞在し、その間、上記プログレスの投稿論文の英文校閲をされたわけです。外国語については多くの国語を解し、日本語も非常に上手です。

(編集委)