APPENDIX A: WRITING A BETTER SCIENTIFIC ARTICLE

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Using examples drawn from the pages of *RMP*, the author presents specific writing techniques that can enhance the sense of immediacy between writer and reader and improve the clarity, economy, and polish of scientific writing. The first half of the article is devoted to elements of good style applicable by anyone, while the second half treats problems often encountered by non-native writers of English.

What sets a first-rate scientific article apart from the thousands of forgettable publications that appear in the literature every year? For a very few, content alone ensures that the paper will be widely cited. But for most, it is the way the article is written. A good article puts us in touch with a good mind (or team of good minds) at work, whose quality is revealed by clarity, economy, order, and perhaps wit. These rather abstract qualities are warmed by the author's effort to share his or her interest in the subject as if speaking with a colleague, presenting the work not as a series of cut and dried results, but as an ongoing process by which understanding is sought. The reader whose interest is thus engaged can then share the author's satisfaction as a solution begins to emerge.

A number of specific writing techniques can enhance the sense of immediacy between you and your reader. In addition, avoidance of some common pitfalls will reduce dullness, wordiness, and pomposity, which – contrary to popular belief – are not desirable attributes in a scientific article, but represent negative values of the clarity, economy, and wit mentioned above. In this guide, I describe practical measures that you, the author, can take to give your writing greater impact, with examples drawn from the work of *RMP*'s contributors. The guide is divided into two sections, one of more general application, for anyone interested in writing better, and the other aimed specifically at the author whose first language is not English.

A. Elements of good style for everyone

1. Active and passive voices

You have heard this before, but it bears repeating: active sentences are more vigorous than passive ones. When you want to put more muscle into your prose style, replace "Science is done by people" with "People do science."

Writers of scientific papers often favor the passive because it relieves them of naming themselves as the ones who conducted an experiment or proposed a theory. Saying that "it was thought that the magnetoresistance could provide an answer" shields the person who thought so from the critical gaze of his audience and is vague enough to spread credit or blame, implying that the writer was not alone in having this idea. The passive voice also provides a way out for those who feel reticent about naming names and pointing fingers when discussing others' work. Keeping names to a minimum, such a writer introduces, say, the work of Erikson *et al.*, and then follows with a three-page description in which "the bubble formation was simulated," "a constant of $a = 1.5$ was assumed," and "agreement with the model of McCray was found to within 3%." There are three problems with this approach. First, it sounds stuffy. Second, it may lead to confusion, especially if other people's models and parameters were adopted by Erikson *et al.* and need to be discussed as well. After a while the reader will no longer be sure whose work is being described. And third, any effort to dissociate science from its practitioners by describing it passively is doomed to failure, since readers not only know that scientists do science, they are very interested in which scientists – it could well be one of their friends or competitors. Changing to the active voice and stating who did what – "we simulated the bubble formation," "McCray assumed a constant of $a = 1.5$," "they found" – will tell readers what they want to know and set the work in the context of human endeavor.

The active voice also encourages economy. Compare the following pairs of sentences:

A review of the main problems in this field was given by Luo *et al.*

Luo *et al.* reviewed the main problems in this field.

A discussion of intrinsic pinning is offered in Sec. VIII.

In Sec. VIII we discuss intrinsic pinning.

In each pair above, the active version uses fewer words. Most readers will perceive this brevity as the mark of a direct and vigorous mind.

There are, of course, occasions when the passive voice is useful. Sometimes you will want to put emphasis on the thing being acted upon, by naming it at the beginning of a sentence.

This problem has been the subject of intensive study ever since 1934.

And, for simple variety, a modest number of passive constructions can lend grace to a piece of writing, especially when no particular agent is being obscured by them:

All perturbations can be naturally divided into two classes.

Abstracts are another place where the passive voice is appropriate. Abstracts appear separately from the articles they describe, in on-line listings and reference works like Physics Abstracts. Use of the first person in such an impersonal setting sounds a bit odd. (However, consider the active alternative, "This article surveys...," "The authors find that...")

2. Economy

A clean, direct style shows respect for your reader's time. While it is possible to be so direct as to be blunt and graceless, most scientific writing suffers from the opposite tendancy, wordiness. One exercise that helps to curb wordiness in your writing is to see how many verb-noun phrases you can replace by simple verbs. For example,

make a decision	decide
experience failure	fail
place under consideration	consider
perform an experiment	experiment
give indications of	indicate
present a discussion of	discuss
conduct an investigation	investigate
make an attempt	try
introduce a replacement	replace

The expressions in the left-hand column need not be banished from your writing. They can be useful for creating parallels, introducing variety, or smoothing a transition. If you find, however, that you are using a great many, be aware that you may be regarded as windy and your papers as needlessly long.

A few other wordy expressions deserve mention here. One is "the fact that." It can always be replaced by a more economical construction:

the fact that Clark succeeded	Clark's success
owing to the fact that	because
despite the fact that	although
he was unaware of the fact that	he was unaware

Another is "the reason... is that" and variants of this pattern. Generally, rearranging a sentence so as to start with a subject and verb produces a more vital sounding statement:

The reason for solving the Cauchy problem first is that...

We solve the Cauchy problem first because...

The main theme of this section is to tell why we have chosen to generalize...

This section presents our rationale for generalizing...

My purpose has been to provide a description of thermodynamic phase transitions.

I have tried to describe thermodynamic phase transitions.

Then there is "the case." Personally, I am rather fond of "In the first case" and "in the second case," but have to grant that "cases" can be totally useless appendages, better amputated:

for the case of	for
in many cases	often
it has rarely been the case that we	we rarely
in the case when	when

If the writer is tempted to use "in the case where," he or she should see the section on grammar below.

3. Forward momentum

Here is an actual sentence from a contributor to *Reviews of Modern Physics*:

> That the wavelength of any oscillator employed must necessarily be very small follows from the circumstance that the length of an accelerator of given energy – i.e., the lengths of the individual drift tubes in an accelerator with a given number of drift tubes (and hence acceleration gaps) – to which a given voltage is applied, and through which a given species of ion is accelerated – is proportional to the period, hence the wavelength, of the oscillation.

Before publication, this sentence was edited to about two-thirds of its present length. Its problem, however, is not length per se. It suffers from the author's attempt to cover everything. The cumulative effect of multiple asides, parenthetical remarks, i.e.'s, and "hences" is to leave the reader feeling like a passenger in a car whose driver starts up, then stops, then starts again, then stops, etc. Moreover, by the time the reader gets to the verb "is proportional," he or she is likely to have forgotten the subject, the length of an accelerator.

Asides and parenthetical remarks can enhance a text. They reflect the way people talk and thus give a conversational tone to any piece of writing. When overused as above, however, they will kill the momentum of the article. To keep the reader moving forward, one should use them judiciously and not place more than one between a subject and its verb, where they become merely distractions.

Here are some examples of sentences that use parenthetical remarks to good effect. The asides serve a variety