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SOME SPECIFIC TIPS ABOUT TECHNICAL WRITING

I. THE WRITING PROCESS

1. Identify your audience and think carefully through how to communicate with them.

2. Identify the goals of your article.

3. Choose carefully the place to publish. Relevant issues: Will it reach your desired audience; does it have page charges; will it accept compuscripts (so as to avoid typesetting errors and proofing headaches).

4. Before starting to write, be sure you know clearly the style requirements of your journal or publisher:

   a. Read its manual of style.

   b. Get copies of several articles or books published in that journal or by that publisher to use as style guides.

5. Identify the level of perfection appropriate for your article, and strive for it. Remember: "perfection is the enemy of good"; but "sloppiness may destroy your credibility".

6. Make a sequence of outlines, e.g.:

   a. First, a long list in random order of all the items to be covered.

   b. Next, identify a few major categories (to become sections of the article) into which the items can be classified; and move each item into one of those categories.

   c. Next, organize the items within each category.

   d. Then, rework the entire outline.

7. Different people prefer different methods of doing the writing. Some remarks about Kip's preferred method:

   a. First I do a very crude introductory section.

   b. Then I work long and hard on the body of the paper, making revisions as I go. The body grows "organically", changing as it develops. A large fraction of my research is done while I am writing the body -- suggested to me by my struggle to make the ideas clear.

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The body, when finished, bears little resemblance to the article as envisioned in my original outlines.

c. When the body is finished, I return to the introductory section and rewrite it completely.

d. Finally, at the end, I write the abstract.

e. The paper by now is on the computer (either because I wrote it there originally or because somebody has word processed it). I will not, except under extreme circumstances, publish with a journal or publisher who resets the article in type; thus, the version on the computer will become the final, published version -- either via compuscript or via photoreproduction of camera-ready copy.

f. I then make at least two passes through the entire paper, checking all equations from scratch (not looking back at the original derivations). This firms up the article and catches typos and mathematical errors.

8. Have your article critiqued by others before publication.

II. ORGANIZATIONAL STRUCTURE OF THE ARTICLE

1. The material to be presented is usually nonlinear in its logical structure. Consider the use of Figures, Footnotes, Appendices, and Boxes (a la MTW) as tools to preserve essential aspects of that nonlinearity in the written presentation.

2. Different audiences will read different parts of the article. Write them accordingly:

a. The title is read by a huge audience. It should give clear information about the subject of the paper and should attract a large fraction of the audience to read further.

b. The abstract is read by a large audience. Make much of it understandable to the nonspecialists among them. Try to attract as much of your audience as possible to read further. At the same time, give enough detail that the specialists (usually the audience you most wish to reach) will want very much to read further. Be as accurate as is compatible with the abstract's short length. Make sure it contains all the main points of the article.

c. The introduction will be read by a moderately large audience. As with the abstract, make it understandable to them, including nonspecialists. [Stephen Hawking's articles since 1973 (after The Large-Scale Structure of

Spacetime) are a good model of how to write introductions that reach wide audiences.] Consider making the introduction an "introduction and summary". Explain where to find, in the body of the paper, the technical details corresponding to the items described in the introduction.

d. The figures will be glanced at and often studied by an audience nearly as large as read the abstract. Consider writing figure captions that enable your audience to understood the figures without reading the text of the article.

e. The body of the article is directed at your most important audience: the specialists in your topic. Don't waste their time by presenting too much material that they already know (unless this is a review article). Make sure the body is very clear to them, and as concise as they would like. Make sure the body plus appendices give sufficient detail that real experts can reproduce what you have done without enormous effort. Don't give so much detail that nonexperts can easily reproduce what you have done, unless you are writing a review or pedagogical article or unless that is compatible with the needs of the experts. Relegate to appendices details that get in the way of the flow of the main presentation.

3. Use sectioning and subsectioning fairly liberally, as a guide to the reader.

III. FIGURES

1. In a technical article figures can be a very powerful tool for conveying information. It is worth spending many hours, even many days developing excellent figures. John Wheeler and Roger Penrose are examples of physicists whose figures are very effective; go look at some of them.

2. Penrose is an especially good expert, in drawings of 3-dimensional things, at the use of perspective, shading, stippling, and carefully placed lines of varying thickness. Study these aspects of his drawings and try to emulate them.

3. Consider the use of computer-generated drawings; when done well, they can come out better than drawings done by draftspersons. For two-dimensional drawings something like Macpaint and Macdraw on the Macintosh is adequate. Good 3-dimensional drawing packages are just beginning to become available at reasonable cost.

IV. EQUATIONS

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1. Special advice if you will be at the mercy of a typesetter: Find out (e.g. in a manual of style or in published articles from the journal or publisher you are using) what kinds of fonts are available, and plan your equations accordingly. When submitting the article, include a copy on which are clearly marked for the typesetter or editor the meanings of various special symbols. If the mathematics is complex then, to be sure the copy editor has not made serious errors, request that you be sent for review the copyedited manuscript before it goes to the typesetter. When checking the galley proofs, check every equation in several different ways, in search of typos: Check against the submitted manuscript; check against your original calculations; even, if time permits, rederive every equation from scratch and check it against the galley proofs. If there are a large number of typos in the equations, request a second set of proofs. Do not assume the publisher will get them right the second time around.

2. In the prose of your article, give your readers detailed instructions as to how equations are obtained, unless it is obvious; e.g., "By combining equations (17), (36), and (12) and then integrating and choosing the integration constant in accord with the boundary conditions (35), we obtain ...".

3. In most journals and books equations are treated as part of the prose, and must be punctuated as part of the prose (with commas, semicolons, or periods at the ends of the equations). Check that you have done this correctly.

4. Mathematical symbols normally should not be used as verbs; e.g. do not write "When the sky is blue, $A=B$." Instead write "When the sky is blue, A is equal to B." Any exceptions should be carefully thought out.

5. Sentences normally should not begin with mathematical symbols; e.g. do not write "H is used to denote the horizon, while J denotes infinity." Instead write "The symbol H is used to denote the horizon, while J denotes infinity."

6. Do not use built-up equations in the middle of text; any built-up equations should be set off as display equations.

7. When an equation is too long to fit on one line, make a careful and wise decision about where it is to be broken and about where, under the preceding lines, the beginning of each subsequent line should be aligned.

8. Make careful decisions about what symbols are to be set in italic font, what in roman, what in bold, etc. For guidance see the manual of style or sample articles. For example, in subscripts and superscripts, any string of two

or more letters that stands for a word or phrase is normally set in roman (nonitalic) font.

9. If submitting to The Physical Review, read the Phys. Rev. Compuscript Manual carefully before word processing your article, and try to adhere to its rules right from the beginning of your writing. This will save grief later. Note that the troff macros on our computers are compatible with Phys. Rev.

10. Give an equation number to every equation that any reader might ever have any desire to refer to. Otherwise, readers will be hampered in their use of your paper.

V. REFERENCES TO THE WORK OF OTHERS

1. BE SURE TO GIVE FULL CREDIT TO OTHERS FOR THE WORK THEY HAVE DONE. No rule of scientific etiquette is more important than this one. Make very clear which things in your article are new and which are not, and cite clearly the origins of the things that are not new.

2. When citing long articles or books, cite the specific section or page or equation in which the reader will find the thing to which you are referring.

VI. PROSE

1. Endeavor to make your prose flow smoothly, even in (especially in) very technical arguments. A major tool for this is to choose phraseology, especially at the beginnings of paragraphs, that refers back in some way (often subtle) to the previous sentence or paragraph. Without such "connecting phraseology", the prose can seem to jump discontinuously from one item to the next and the reader can lose a sense of where you have come from and where you are going.

2. Use the following techniques to make logically complex material read clearly:

   a. The use of an introductory paragraph, at the beginning of a long argument, which explains that the long argument is now beginning, gives a rough idea of how long it will be, and explains what its various pieces will be.

   b. The use of a sentence at the beginning of each piece of an argument, which says what that piece will be about, and a sentence at the end, which says that that piece has now been finished and you are going on to the next piece.

   c. The use of "parallel structure" (i.e. the same structure

used two or more times in succession) in prose and
punctuation, to show that certain items are related to
each other.

   d. The use of numbering for items (e.g clauses of a
   sentence) that are of a similar logical sort -- (i),
   (ii), (iii), ... or (a), (b), (c), ...; but not (1),
   (2), (3), ... because that can be confused with
   equation numbering.

   e. The break up of long, complex sentences into several
   short sentences, except where parallel structure or
   numbering is used to make the long sentences
   understandable.

3. Use a writing style that is appropriate to the audience you
   are trying to reach. An example of a failure in this
   respect is Hawking and Ellis, "The Large-Scale Structure of
   Spacetime". Much of it is written in the language and
   style of mathematicians although it was directed at a
   physics audience. Hawking tells me that, in retrospect, he
   regrets the style. Contrast it with Hawking's more recent
   papers and with those of Penrose, when Penrose is writing
   for physicists. Similarly, a style appropriate for
   theoretical physicists normally is not appropriate for the
   audience of The Astrophysical Journal.

4. Try to avoid sexist phraseology -- particularly masculine
   pronouns (he, him, his) -- unless referring to a specific
   masculine person. Preferable is "one" and "one's" or
   "they", "them", and "theirs". Example:
   Instead of "The reader will understand this if he has
   studied Hawking and Ellis," write "Readers will
   understand this if they have studied Hawking and
   Ellis". But do not mutilate the grammar of the
   English language with "The reader will understand this
   if they have studied Hawking and Ellis."

   5. Some specific items:

     a. Several occurrences of the same word in one or
      neighboring sentences can "resonate" with each
      other in readers' minds, thereby distracting their
      thoughts. Avoid such resonating sets of words,
      except where they are used deliberately as part of
      parallel structure to carry a complex argument or
      as connectors to carry a smooth flow of the prose.

     b. Normally avoid, in mid-paragraph, changing voice
      (e.g. from active to passive or imperative), or
      changing the type of person who is envisioned as
      carrying out the actions of the paragraph (e.g.
      from "one" to "they" or "you").

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c. Normally avoid double negatives -- not simply one right after the other, but any use of two negatives in a single clause of a sentence.

d. Normally (but not always) avoid split infinitives.

e. Normally avoid dangling participles.

f. Normally place near a word or phrase all of its modifiers and all other things that are logically tightly connected to it; don't let them dangle off in some distant part of the sentence. Example:
"We shall study spacetimes that are, in some suitable sense to be described below, similar to Schwarzschild." Here the word "are" dangles; to remove the dangle, write: "We shall study spacetimes that, in some suitable sense to be described below, are similar to Schwarzschild."

g. Normally avoid splitting up the modifiers of a word or phrase, with one set of modifiers in front and the other behind; instead put them all on the same side of the word or phrase. Example:
"These equations, when written in terms of partial derivatives, become a system of first order linear partial differential equations, after we combine with Eq. (17)." Here "become a system of first order linear partial differential equations" is modified, in similar ways, by the phrases preceding and following it. This can be repaired, e.g., by "These equations, when written in terms of partial derivatives, and when combined with Eq. (17), become a system of first order linear partial differential equations."

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