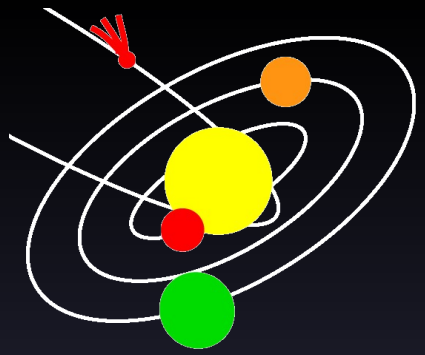

SOLAR SYSTEM SCHOOL

Solar System School

How to Write a Research Paper

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with help from:
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MPS

Some Basics

- Scientific progress has been the basis of much of the improvement in our standard of living and quality of life. Science has also provided answers to a row of long-standing and deep questions (and many, many not so long-standing and not so deep questions as well).

- What makes science so strong?

1. Independence and freedom of research (only within limits for PhD students...)
2. Open communication of methods, results, data, etc. conferences, seminars, **publications**
3. Peer review (refereeing) and critical discussion of results
4. Repeatability of work and compatibility with other results
5. Honesty (no plagiarism, making sure you have made no mistakes, only publishing what you really have found)

Some more Basics

- One (maybe the most) important difference between academic & industrial or military research is making your methods and results public
  - Publication means that results can be openly discussed, tested and compared (Pt. 2 is prerequisite for Pts. 3+4).
  - The checks and balances of science require publication. Also, we need to really trust the results we publish
  - In the real world: Secrecy is often maintained (regarding ideas, techniques, or new results) until published
- We **must** publish our results, even if we don't like to write. Many famous scientists also didn't like to write. E.g. Darwin, who once wrote: "A naturalist's life would be a happy one if he had only to observe and never to write."

Before starting to write

- Each paper must provide new, non-trivial knowledge, insight
- Write the paper only when you have final or near-final results
- Keep a written record of your work as you do it, to avoid forgetting what you have done. After 3 months I have generally forgotten the details of what I did (sometimes after only 3 days)
- For the same reason start writing a paper soon after getting your final results – do not wait too long after that
- Leave yourself enough time to write: Even if you have “final” results, you will often need to redo some work, or do some more work once you start to write
- Discuss with your supervisor. He/she can judge best the best time to start writing a paper

Before starting to write

- **Think** early about what you want to communicate
- Identify the main aim & message of your paper:
  - The authors need to agree what will be the main message of the paper. Discuss with your supervisor and/or co-authors.
  - Papers with a single, clear message are the easiest to read and to remember
  - If there are too many equally important messages, then the paper can become difficult to digest for the reader
  - If you have many important results you may want to write multiple papers. However, do avoid MPU papers (MPU = Minimal Publishable Unit). Each will give you an additional paper, but will also give you a poor reputation

Before starting to write

- What kind of publication is it? E.g. Journal paper, review paper, conference proceedings paper, etc.?
- Contents, format (& partly style) differ:
  - **Journal paper: presents final, substantial and original results, careful description of technique etc., it gets refereed before publication** → Here we deal mainly with journal papers; since they are by far the most important
  - Review paper: summarizes, evaluates and synthesizes results already published elsewhere.
  - Proceedings paper: Often preliminary results, usually short (page limits), sometimes speculative (not as important as a journal paper, e.g. hardly gets cited, people wait for the journal paper to appear)
  - PhD thesis: Combination of above. E.g.: 1st chapter like review paper, later chapters like journal papers

Before starting to write

- If it is a journal paper, choose the journal. Strictly speaking, this is not necessary at this stage. However:
  - Implications of possible page limits (e.g., letters)
  - Implications of format and style requirements (e.g. style of references, first person singular allowed or not, B&W or colour,
  - Implications for page charges (does your supervisor have or want to provide the funds to cover these?)
- Also, different journals may have different readerships. You may be addressing different communities, so that it is important for you to know who your intended audience is
- Your supervisor should guide you with choosing a journal

Before starting to write

- Read the literature! This is VERY important for 2 reasons
- 1. To learn how to write scientific texts
  - You will find out how professional scientists write. Learn from their style and language (the language of science is not the same as everyday language) Riccardo Giacconi (Nobel prize 2002) has his own definition of the “language of science”
  - Best for this purpose is to choose papers by experienced native speakers. Ask your supervisor to give you papers by a colleague who writes particularly clearly
  - Read carefully and critically (look at the style separately from the content), compare papers and practice writing yourself.
  - Write the notes of your work in a style appropriate for a research paper. You will notice that your writing skills will improve with time

Before starting to write

- Read the literature! This is VERY important for 2 reasons

- 2. To identify what is new about your work compared to what has already been published & to better interpret your results
  - Your work must be embedded in what has been done before: each paper is another paragraph (or at least a footnote...) in the story of science
  - I.e. you must first know what else has been done and what hasn't been done. You will put this into the introduction, but it is best if you know it even before you start writing the paper

You need to read the literature. This is something YOU must do. Don't expect your supervisor to do it for you

Before starting to write

- Put together the structure of the paper.
- A generic structure is:
  - Title, authors, affiliations, possibly key words, etc.
  - Abstract
  - 1. Introduction
  - 2. Methods & Materials
  - 3. Results and
  - 4. Discussion & Conclusions
  - Acknowledgements (optional, but most papers have them)
  - References
  - Appendices, online material (optional)
- IMRaD is a typical structure (more complete: AIMRaDAR). In some cases (e.g. review papers, short papers in conference proceedings) other structures may be more appropriate

Before starting to write

- Structure (contd.)
- The above structure is only a guide, but a pretty widely used and good one. You can deviate from it, but do so only if there is a good reason
- You can also add more structure. Thus, you can divide long sections (e.g. Results) into subsections
- Once you have a basic structure, you may want to make a list of things that you would like to put into each section.
  - Some people like to make such an outline first and then fill in the details later
  - Others prefer to start writing and then move pieces of text (e.g. groups of paragraphs) around until they have the right structure

Before starting to write

- Select which results to show
  - Often helpful: first choose the figures to be published
  - Criteria: Does the figure show something new? Is the figure important for understanding technique or results?
  - Remember: your interest in the details of your work is larger than that of the reader be selective!
  - Also Remember: your knowledge of what you have done is larger than the reader's Be sure you include everything needed to explain to the reader what you have done!
    - What level of knowledge does the reader have? Aim for other PhD students in the same field
  - Talk with your supervisor and/or any other co-authors at this point. Authors need to agree on what will be shown in the paper and what will not

Before starting to write

- Practice your english and if necessary improve it (Giacconi: the language of science)
  - Remember: A paper is more likely to be read if it can be understood, i.e. if the language is clear and correct. Many journals have copy editors, but if the paper has poor language even they will make mistakes (misinterpretations)
  - Also, a paper can be rejected due to poor language
  - Don’t even dream of publishing in another language than english if you want your work to be noticed.
  - Improving your english is one of the most important things you can do
- You might need to use LaTeX, although journals increasingly are also allowing other word processing systems

The Title

- The title often decides if the paper is looked at by colleagues:

  So many papers, so little time!

  - I first check the title (& authors). If interesting I look at the abstract, then possibly at the figures, then, if the paper is particularly interesting at the results and the conclusions sections & finally, only for few papers, at the methods. Many other scientists scan the literature similarly
  - Many computer searches concentrate on the title: they will find a paper only if the words being searched for appear in the title
  - Even if abstract and full-text searches may be available, they will often return many many entries. Restricting a search to the title makes it easier for the person carrying out the search

Authors & Affiliations

- Authors: All authors MUST have read the paper and MUST agree with its contents
  - If it turns out that there is an error in the paper, or if one of the authors cheated, then all authors are held to blame
- Affiliation: Give the whole address when writing the affiliation of each author. E.g.
  - Max-Planck-Institut für Sonnensystemforschung, Max-Planck-Str. 2, 37191 Katlenburg-Lindau, Germany (till 31st Dec. 2013 :-)
  - Alternative: Max Planck Institute for Solar System Research
- Affiliations are important for your institute & university
- E-mail address is just as important (increasingly required by journals)

Abstract

- Golden rule for abstracts is the same as for women's skirts: Short is Sexy
  - → Abstract should be ≤ 5% of total length of (journal) paper
  - → Another guideline: absolute length of abstract should generally be ≤ 200 words, irrespective of length of paper (some journals have hard limits on the length of the allowed abstract)
- Abstract is a condensate of paper in one paragraph
  - Start with typically 1-2 sentences on aims & possibly context
  - Then a very short description of technique
  - Finally bring the main results & major consequences
- The journal Astronomy & Astrophysics offers a structure for abstracts (even more detailed)

Abstract

- I suggest using the active voice: “The temperature rose” rather than the passive “A rise in temperature took place”
- First person (“We have shown…”) is often not used. I find it o.k., but first check if your journal allows this
- No figures, no tables, no footnotes, no references to other places in the paper
- Avoid if possible references to other papers (some journals do not allow them at all). Exception: if paper mainly checks results of another paper, it may be o.k. to add reference
- Keep abbreviations, equations and symbols to a minimum
- Make sentences short (this is a good idea anyway, also for the rest of the paper)

Abstract: an example

Introduction Aim+Method Results Discussion

The extension of the sunspot number series backward in time is of considerable importance for dynamo theory. We have applied a physical model to records of the 10Be concentration in polar ice to reconstruct sunspot number between the year 850 and the present. The reconstruction shows that the period of high solar activity during the last 60 years is unique throughout the past 1150 years. This nearly triples the interval of time for which such a statement could be made.

80 words total

Write the abstract at the very end, after completing the rest of the paper, i.e. once you have found the best formulations for your main results and are firm about the conclusions

Abstract

- One more thing: After you have written the abstract, check it for consistency with rest of paper
  - Is everything said in the abstract also said in the paper? The abstract should NOT contain any new information that is not already present in the body of the paper
  - Does the abstract give all the main results & conclusions? It should not contain the details, but should not be missing the main results and main conclusions

The Introduction

- The introduction serves different purposes:
  - It states the general topic (subject area) of your work
  - It gives the context of your work
  - It gives the aim of your paper
  - It tells what is new about your work
  - It may give an overview of the structure of your paper
- At the beginning of the introduction describe the subject area of your work. What field does it deal with? This need not be longer than 1-2 sentences (not all introductions do this, but it is a good idea to clearly identify the subject area of the paper)

The Introduction

- **Context of your work:**
  - More important and longer is background and context of your work, i.e. what has been done before. This involves a short & balanced overview of the relevant literature
  - Keep the overview reasonably short: the introduction of a research article is not a full-blown review. HOWEVER, do cite the papers that are closely related to yours, or are directly relevant for your paper
  - Balanced: If there is a controversy, cite papers that favour both sides. Do NOT cite only or mainly papers by you or your supervisor, or your institution, or your country!

The Introduction

- **Context of your work:**
  - Move from general to specific First discuss and cite the papers with basic, more general results (or reviews, which allow you to reduce the number of cited papers). Then move to the papers directly related with your work
  - Avoid, if possible, citing general textbooks (general physics, astrophysics, galaxies etc.) since they contain things that are considered “common knowledge”. Also minimize citing not widely available sources (e.g. theses, proceedings), or non-English language articles (the reader must be able to retrieve the information and read it). Best is to cite primary and review literature articles in refereed journals and review articles

The Introduction

- **Aims of your paper:**
  - Very important: Goals of your paper.
  - Say why present work needs to be done. Why it is important
    - E.g. because there is a gap in earlier work, which your work is now filling
    - Or you are using a new method, or improved data, or …
    - Or because there was an error in an earlier paper
    - If criticism of earlier work is necessary, try to be mild. You don't want others to be too harsh about your work either
  - State how you approach the problem 1/2-3 sentences on the method used (e.g. "We employ 3-D radiation-MHD simulations to study ….")

The Introduction

- **Aims of your paper:**
  - Possibly also point out restrictions/assumptions (given in detail in Methods & Materials). E.g. “Our simulations are restricted to ideal MHD…” Plus state your main assumptions (E.g. “We assume that the object remained unchanged over the 7 nights of our observations …”)
- Often done, but not necessary: give structure of remaining paper in last paragraph of introduction. E.g. “In section 2 we describe the data and provide a summary of the reduction procedure…”
- Many students find the Introduction the hardest section to write. They write it at the end, or even ask their supervisors to write it. Writing the Introduction is good practice. It forces you to learn what others have done

Plagiarism

- Plagiarism = including text from another published source (a paper, a book, a website, a PhD thesis) without putting it in quotation marks "…" and/or without referencing the source
- Copying sections or paragraphs from other papers, including your own, may seem inviting since they are already well formulated. If you do that you may end up with a paper that is both "good and original", but "the parts that are good are not original and the parts that are original are not good" (Samuel Johnson).
- Students caught plagiarising get thrown out of their PhD programs
- Plagiarism is not worth doing! You are risking far too much

Methods and Materials

- Describes the instruments and data used, as well as the analysis techniques. It may be called differently or can be broken into 2 or more sections, or subsections
- Examples of alternative section titles:
  - Computational technique (appropriate for a numerical paper)
  - Instrument and measurements (e.g. if a new instrument is being described or used)
  - Data and analysis technique (e.g. if the analysis technique is non-standard or complex)
  - Instrument and observations + Method of analysis (Section broken into 2 sections)

Methods and Materials

- Scientific results must be reproducible. Methods and Materials section is key to ensuring reproducibility of your results it describes what you have done, how you have done it and with which tools
- Times & dates of your observations can be important, e.g. when studying variable phenomena (e.g. a stellar outburst). Also allows readers to check your results with the same data, e.g. from space mission (reproducibility)
- This section is often studied carefully by the referee. It can decide whether he/she feels that the results can be trusted. If he/she feels that the technique is weak, the paper will be rejected

Methods and Materials

- Find the balance between
  - Describing everything important
  - Leaving out everything not needed

} Also important for all other parts of a paper

- Rule of thumb:
  - New method, new instrument, new type of data Describe in detail, since required for reproducibility
  - Known method or instrument, previously used and described in other paper(s) Often a reference and a short summary is sufficient
- Do not repeat published descriptions cite the paper giving the description (possibly with short summary)

Methods and Materials

- Often a figure can illustrate & clarify a new method, or an unusual instrumental setup. More about figures later
- A table can also be quite useful in this section
  - E.g. to list the observations and data sets used
  - or for a numerical paper the various runs with a code (e.g. with different parameters). Make sure that you identify the parameters that are changed and give their values

Results

- The core of the paper, where the results obtained during the long labour of research are presented
- Be concise. Pre-select the results (i.e. identify the important and new results) before writing about them in the results section

Keep in mind:

The fool collects facts, the wise man selects them

(John W. Powell)

(but don't try to be too wise too early! First collect all the facts, then select them)

More Results

- What to put into the Results section and what in the Discussions section?
- General guideline (but there are exceptions)
  - In the results section you only describe the results, but do not interpret them or put them in context (comparison with literature)
  - In the discussion section provide the interpretation and the comparison with the literature, without repeating all the results

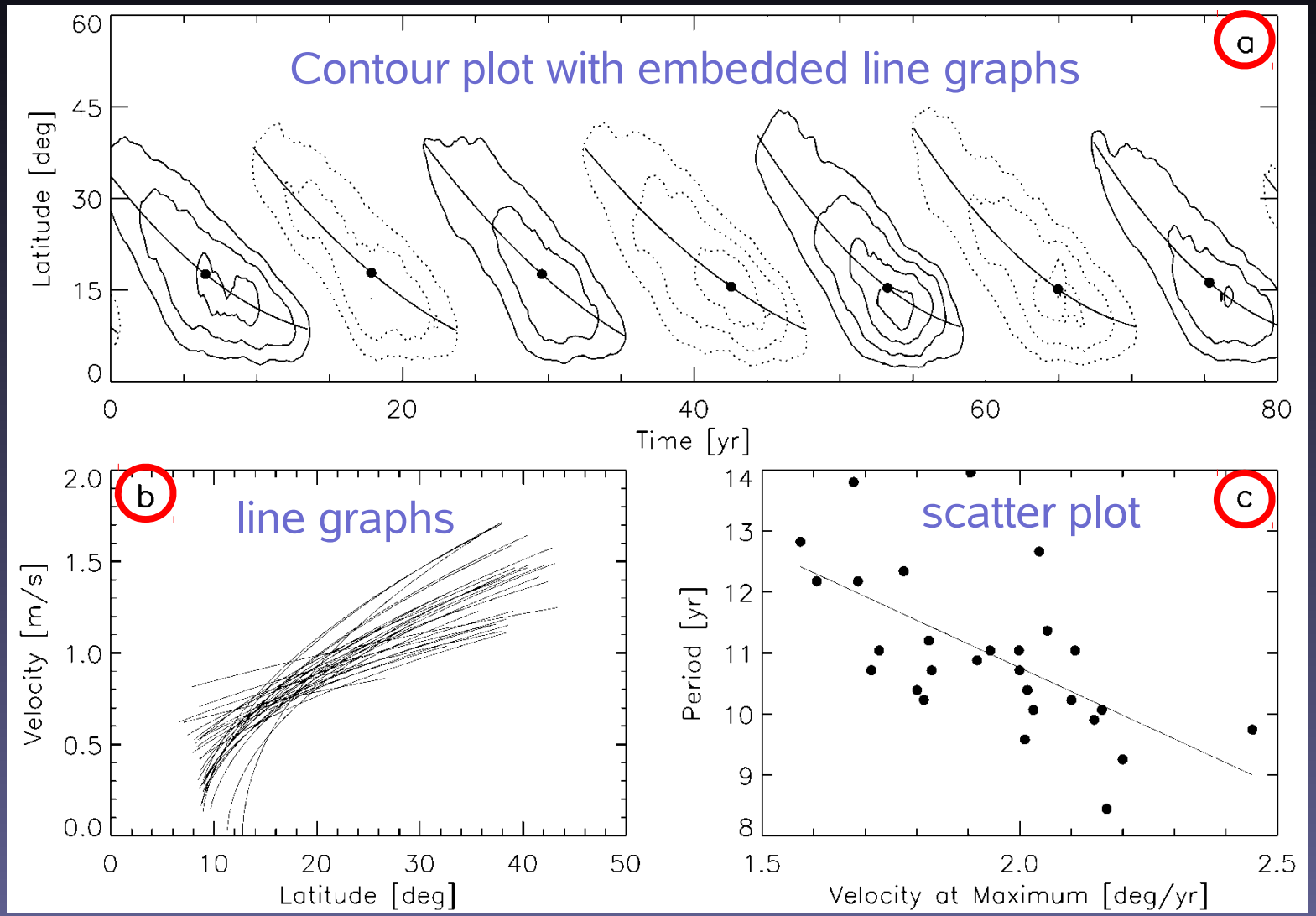
Results: Figures

- One way to structure the Results section is to write it around the figures and tables presenting the main results.
- However, do not forget to make a logical order! □ Make a story
- First prepare & order the figures & tables presenting the results. Then write the main text following them
- Each figure must be referred to in the text (with Fig. 1 being the figure first referred to in the text, Fig. 2 being the next referred figure, etc.). Same is true for tables

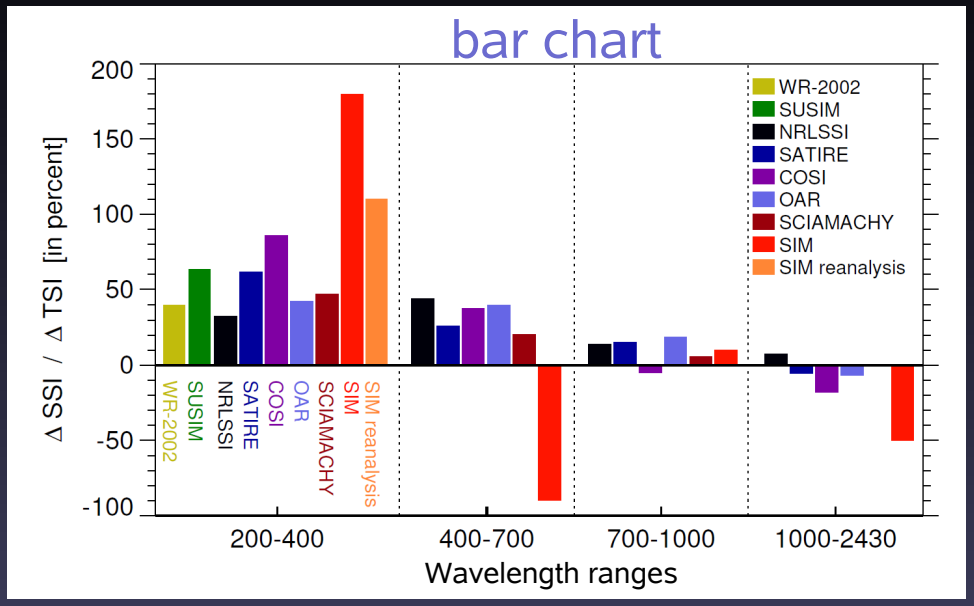
Results: Figures

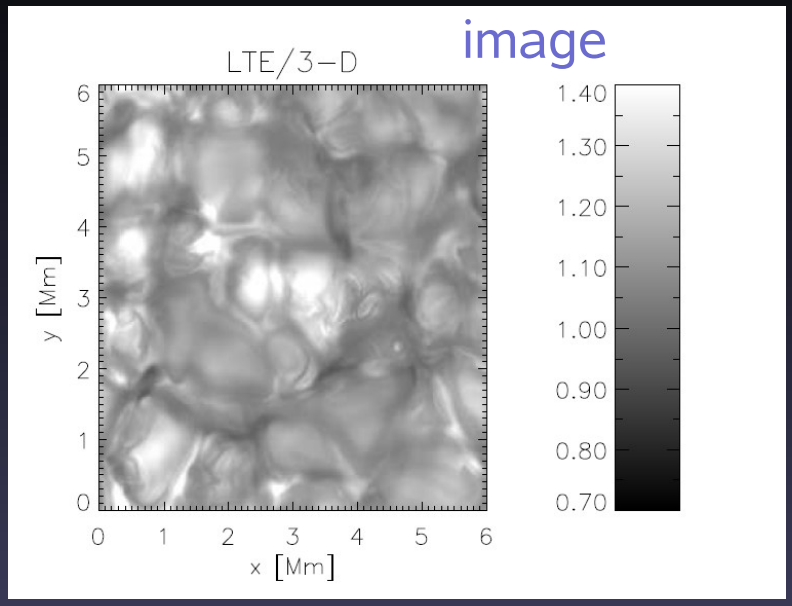
- Each figure must have a **caption**
  - Captions should be short, but self-explaining, since often figures are looked at before the text is read. If symbols or abbreviations are used, then they should be (briefly) defined in the first figure caption in which they appear
  - Captions should only clarify what is plotted and not try to interpret the figure. Interpret and discuss the figures in the main text only
  - Captions are generally put below the figure (usually done automatically by journal style file)
  - Use letters to identify subfigures. E.g. refer to them as "Figs. 1a and b". This is much more concise than "upper left and upper right panels of Fig. 1"

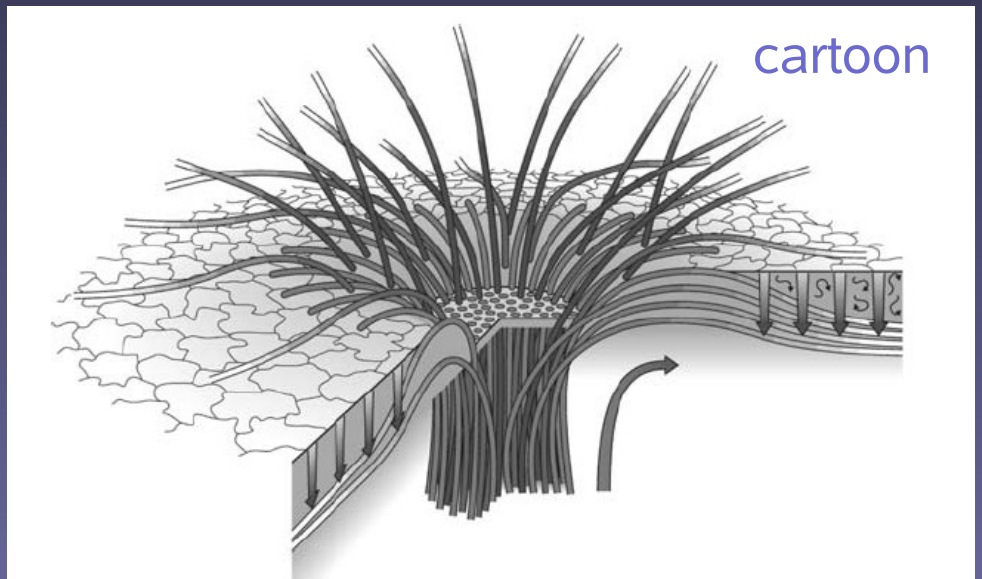
Example figures

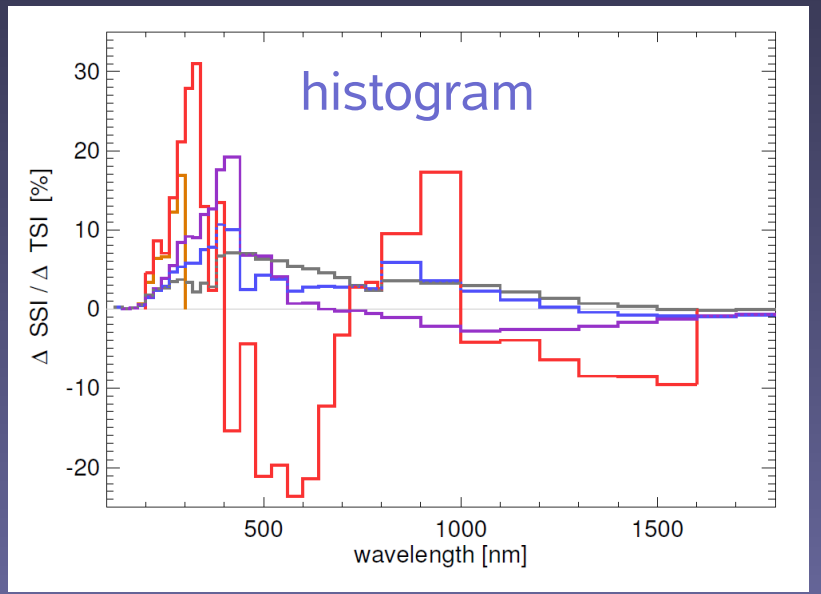


Example figures









Anatomy of a Figure

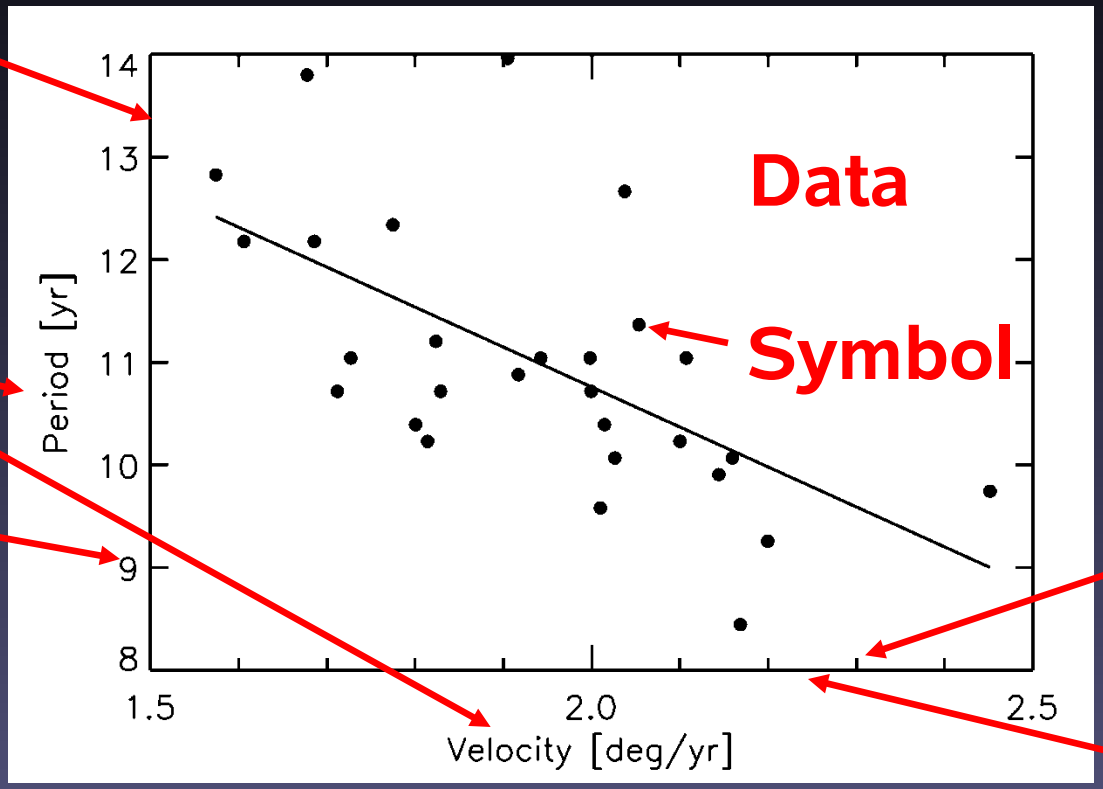


Figure 1. Solar cycle period vs. latitudinal drift velocity at cycle maximum, taken from an $\alpha\Omega$-dynamo model. The dots represent the data of 28 simulated cycles and the line denotes a linear least-square fit

What to observe when plotting figures

- Line thickness, image resolution
- Labels, font type & size

} Depend on journal & final size of figure

- Number and size of major and minor ticks
- Axes ranges (round numbers, fill the frame!), linear/log scale
- Line style, symbols (type & size), color (cost!?). In final figure, label fonts should have same size as main text fonts
- Give a key to symbols (either in plot or in caption)
- Don’t overload figures (do not plot many different quantities)
- Caption: must give all the information needed to understand the figure, but is not a discussion (possible exceptions; e.g. main results).

Tables

- Make a table if you have multiple numbers to show
  - and you cannot put them into a figure,
  - or if the exact numbers are important
- Remember, figures are generally easier to read than tables
- Tables may also be useful in the Methods section – e.g. a table of observations
- Each table must have a title. Keep it short
- Each table must be referred to in the text

An example of a short Table

Table1. Short caption above table.

Model	l [m]	v [m s^{-1}]
A	1	10
B	3	−12
C*	5	15

*footnote

Discussion and conclusions

- In this section the already presented results are discussed and conclusions are drawn from them
- Sometimes broken up into separate sections, one entitled “Discussion”, the other “Conclusions”
- You may repeat the MAIN result(s). However, avoid presenting again all the results found (unless the paper leads to a single or just a few major results)
- This is often a difficult section to write. Drawing sound conclusions from experimental or theoretical results is not always straightforward. It is an exercise in logic, requires some knowledge of the literature & experience
- You must have robust evidence for any conclusions you reach

Acknowledgements

- The acknowledgements are placed between the end of the regular text and the references
- People who have contributed to the paper, but not by a sufficient amount to be included in the author list, should be thanked in the acknowledgements
- Discuss with your supervisor, which people should be acknowledged
- Often you need to acknowledge your funding agency (some of them require it!)
- **You must acknowledge the IMPRS**

References

- Important! Check style manual of journal to which you wish to submit the paper. Journals have widely different styles for references and from time to time change their reference style

- In astrophysics: alphabetical and chronological, e.g.

Aabacher A., 1999, J. Irreproducible Res. 15, 16

Bardot B., 1988, B&B 1, 1111

Chaplin, C., 1977, in Soundless Movies, ed. C. Cardinale, Hollywood University Press, Hollywood, p. 777

Duck D., 1966, The adventures of Daisy D., Disney Academic Press, Disneyland

Duck D., and Mouse M., 1955, Goofy's Mag. 13, 13

Duck D., Mouse M., and McDuck S., 1933a, ApJ 33, 333

Duck D., McDuck S., and Mouse M., 1933b, ApJ 44, 444

References

- Some journals require paper titles and/or end-page numbers. E.g. Kong, K., 2005, Hanging out on the skyscrapers of New York, Movie Monthly, 1001, 2001-2002
- Other journals: references are numbered in the order in which they are cited in text. Best use automated numbering scheme (provided by, e.g., LaTex)
- If you are using unpublished data or results of another researcher, then cite him/her in the text. E.g., (M. Monroe, 1944, private communication). But: Ask before you cite!
- No private communications or unsubmitted papers in the reference list. Keep such citations strictly to the main text and keep them to a minimum!

References

- Many errors are propagated in References
  - Are all papers cited in text also present in the references and vice versa?
  - BibTeX is a great help in establishing consistency
  - Have you really included the reference to the correct paper? I have often found that a student has put in a reference to a conference proceedings paper with little info. instead of citing the journal paper of the same year
  - Make sure the references are correct (up to 25% refs in literature are incorrect)!
    - Check in a data base, such as ADS, which provides references in BibTeX format
    - However: ADS also has errors Best is to check original paper!

After finishing to write

- First revise what you have written
- Important: Check for consistency. Make sure that you say the same thing everywhere in the paper. Inconsistencies can easily creep in during the weeks spent writing different parts of a paper, but they can be noticed when reading it in one go
- Then: Revise again!
- Only then: Show the paper to your supervisor and/or co-authors

Style

- Scientific publications have their own style, different from the spoken work, different from the style of newspapers, or most literature
- The aim of a scientific paper is to transmit what you have done and the results you have found. Remove everything not needed for this
- The style should be precise, clear, simple and concise (i.e. short)
- Golden rule No. 1 of paper writing style: KISS

  Keep It Short & Simple
- Golden rule No. 2 of paper writing style: KISS
  (for those not paying attention to Golden Rule No 1)
  Keep It Simple, Stupid!

Style: simplicity

- Write complete, short and simple sentences.
- An example of a sentence that is perfectly correct, both in language and content, but does make heavy reading:
  - "The apparent galactic contrast, given here by the RMS intensity contrast of NGC 1048, in Hubble filter observations, restored by the deconvolution with the PSF, exhibit reasonable agreement with that in numerically synthesized intensity maps, demonstrating that the PSF, though inexact, returns a competent estimate of the aperture diffraction and stray light-free contrast."
  - 7 commas in this one sentence --> break into multiple sentences...
- Referees often complain that a paper is too difficult to read or obstruse, but no referee ever complained that a paper is too simple to read… (experience of Maria Cruz, Astronomy Editor of Science)

Style: Precision

- **Be precise!**
- It has been said that “fuzzy writing reflects fuzzy thinking” □ show that your thinking is not fuzzy
  - Choose your words carefully to say precisely what you need to say
  - Provide numbers whenever it makes sense
- Choose your words carefully: Try to avoid writing things in a way that can be misunderstood. This is not easy and requires practice. It leads to language that is different from everyday english □ scientific english

Style: Precision

- Provide numbers whenever it makes sense
- → E.g. instead of saying "wave a is stronger than b", give a number: "amplitude of wave a is 3 times that of wave b"
- Use a given symbol only for one quantity throughout paper
- Define every variable, symbol and acronym the first time it appears
  - E.g.: "Another name for Father Christmas (FC) is Santa Claus (SC). FC does most of his work in the run-up to Christmas and so does SC, of course." Avoid using too many acronyms and abbreviations
- Give error bars for measurements & derived quantities. Also helps to fix the number of digits to show: E.g. should you write 0.123456 or 0.1? If error bar is ±0.3, then 0.1 ± 0.3 is obviously better

Style: Equations

- Make equations part of the text, even if they are written separately, e.g. in LaTeX display mode. Use normal punctuation (commas, full stops) after equations
- Equations generally do not form new paragraphs
- Example: "After lengthy calculations Eqs. (3) and (4) can be reduced to

$$y(t) = \int_0^{2\pi} \sqrt{t^n(x) + \sin t(x)}\, dx, \qquad (5)$$

$$\frac{dy}{dx} = e^{-i\omega t(x)} - t(x), \qquad (6)$$

where t is now a complex function."

Style: Don't forget the reader

- Write at a level for PhD students working in the same general field. E.g., a planetary atmospheres paper should be aimed at atmospheric planetary scientists, but maybe not specializing in the same planet.
- The 4 principles of writing for the reader:
  - The clarity principle: Make things clear to the reader, but do not give more information than is necessary
  - The reality principle: Assume that readers know how the world works (no need to tell them all again), but tell them anything you believe they may not know & do need to know
  - The relevance principle: Stick to your topic and do not lose the aim of your paper from sight
  - The honesty principle: State only what you can provide evidence for

Style & language

- Scientific english would be a lecture course in itself
- Here I consider only a few aspects, concentrating on common errors and useful lists of words
- For example, it is important to have a handy list of verbs to use. E.g. for describing what is seen in a figure, avoid using "shows" 20 times over. Alternatives:
  - displays, exhibits, depicts, presents, renders, pictures, illustrates, highlights, reveals, discloses, clarifies, makes visible, indicates, uncovers, unveils, explains, can be seen from Fig. ... , can be deduced from Fig. ..., in Fig. ... we plot, sketch, draw, Fig. ... is a plot of, ... is a sketch of, ... is an illustration of. And many more possibilities!

Style & language

A collection of verbs used in describing cause-effect relationships and correlations:

actuate
activate
affect
be associated (with)
be conducive (to)
be due to
be linked (to)
be responsible (for)
blame (on/to)
bring about
cause (to happen)
compel
control
contribute (to)
correlate (with)
counteract
depend (on)
effect
induce
influence
initiate
lead (to)
make
originate (from)
produce
prompt
react (to)
relate (to)
respond (to)
result (in/from)
spark
stimulate
trigger

- Example: Putting lasagne on the table is responsible for / brings about / induces / initiates / leads to / produces / results in / prompts / triggers / stimulates a feeding frenzy by Garfield

Style & language

- Also, do not use repeatedly the same word in the introduction and discussion sections when describing what various authors have said or done
- Similar verbs that say nearly the same thing:
  implied, mentioned, noted, found, demonstrated, showed, stressed, detailed, discovered, uncovered (by), revealed, obtained (a result), ….
- Example: M. Jagger (1965) implied / mentioned / noted / found / demonstrated / showed / stressed / detailed that he can get no satisfaction

Logical sequences and connectors

- Typical problem with papers written by beginners. Thoughts are put to paper, but without making sure that each sentence follows logically from the previous one
- **Make a story!**
- Important: The sentences within a paragraph should follow a logical sequence (i.e. it should be possible to rearrange the sentences and someone else would still be able to put them back into the correct order again). Examples are given in following slides; as an exercise)
- Connectors are a key to making the text flow

Killer cows and connectors

Connectors & Modifiers

lead from a (part of a) sentence (thought) to the next

A few examples (not exhaustive)

Connectors and Modifiers

Indicating an addition:

additionally	as well (as)	furthermore
also	at the same time	in addition
as mentioned (above)	besides (informal)	moreover

Indicating a parallel (also for clarification):

by the same token	in the same way	that is
equally	likewise	i.e.
in other words	similarly	like
indeed	similar to	

Connectors

Contrasts and alternatives:

all the same
alternatively
although
apart from that
by contrast
conversely
despite the fact that ...
even so
surprisingly
even though
but
still
in spite of
whereas
even though
however
in comparison
in contrast to + noun
instead (of ...)
on the contrary
on the other hand
nevertheless
nonetheless
rather (than)
still (infml)
though
though (infml)
while
yet

Indicating a cause: (cause and effect)

accordingly
as a consequence
as a result
because
consequently
for
hence
owing to ...
thereby
due to
owing to
leading to
since
so (infml)
therefore
thus

Ordering points:

first
second
secondly
third
next
now
continuing
further
thirdly
then
finally
lastly
as the next step
after
before
in conclusion
in summary
to summarise
to sum up

Connectors

Emphasis:

above all
actually
as a matter of fact
in actuality
in fact
essentially
Primarily
indeed
in particular
let alone
naturally (infml)
of course
interestingly
Most important
specifically
surely
to put it mildly
to say the least
without exception

Modifying a statement: (some: confirming a statement)

according to ...
as a rule
by all accounts
for the most part
generally
in general
in most cases
in practice
in principle
in theory
theoretically
to some degree
to some extent
to the best of my knowledge
in accordance with
typically
usually
traditionally
normally
naturally
clearly
ideally
confirms

Continuation of explanation

In this context
In this perspective
In this connection
In connection with
In this respect
Here

Connectors

Examples

for example
as exemplified by
e.g.
for instance
as illustrated by
shown by
as shown by
as an illustration
like
such as

Reintroducing and comparing

in connection with
focusing on
in comparison with
regarding
with respect to
with regard to
for
compared with
relative to

Conditional

In that case
given that
once that
otherwise
provided that
as long as
given
now that
while
until
if
now that

Generalization

In general
in a broader context
generally speaking

Style and language

- A common error Germans (and some others) tend to make:
  - WRONG: A and B allow to record the velocity
  - CORRECT VERSIONS:
  - A and B allow the velocity to be recorded
  - A and B make it possible to record the velocity
  - A and B allow recording the velocity
- Another little hint: Don't use "don't", do use "do not". In general, avoid all contractions in scientific texts, e.g. can't cannot, isn't is not

The refereeing process

- Every suitable paper submitted to a respectable journal is sent to a referee to make comments on how to improve the paper and to advise the editor. Some journals send papers to two referees. The editor decides to accept or reject the paper
- The referee will generally advise to (categories may differ from one journal to another)
  - publish without changes (rare)
  - publish with minor changes (the referee does not generally see the modified version again before printing)
  - publish with major changes (the referee is sent the revised version to comment on)
  - not publish in its present form, but resubmit after major modifications (to then be treated like a new submission)
  - not publish at all

Most common reasons for rejection of a manuscript

MOST COMMON REASONS FOR REJECTING ARTICLE MANUSCRIPTS
(Cited by 85 Editors of Scientific and Technical Journals)

Reason	Number of Respondents
Subject	
Not suitable for journal	63
Not timely	4
Coverage	
Questionable significance	55
Questionable validity	39
Too shallow	39
Too exhaustive	8
Length	
Too long	26
Too short	4
Presentation	
Bad organization	35
Ineffective expression	33
Ineffective or unusable illustrations	11
Failure to follow style guide	4

Dealing with referees' reports

- At first sight referees' reports often look more negative than they really are

- Read the report, show it to your supervisor. Then put it away for a few days (to calm down). Only then read it again & make the requested changes to the paper

- Send a reply to the referee along with the revised paper:
  - In the reply, point out how you have taken his/her comments into account in the revised manuscript
  - If you disagree with the referee and haven't implemented one of his/her suggestions, then explain why not

- Referees are (usually) not stupid. If he/she misunderstood something, then the paper is not clear → Make it clearer

Making your paper available to the community

- Publication takes 4-10 months from submission
- Scientists therefore often used to send (printed) “pre-prints” to each other
- Now electronic preprint servers do the job:
  - I suggest you put your paper on the Arxiv or astro-ph server
    http://xxx.lanl.gov/ (all physics + maths)
    http://xxx.lanl.gov/archive/astro-ph (only astrophysics)
  - Astrophysics (incl. solar) papers put on this preprint server are cited twice as often as papers not on the server (open access!!)
  - It is generally wise to wait until your paper is accepted for publication before you put it there! Otherwise you might have a paper in public that bears little resemble with the published one…
  - Citing papers on astro-ph: cite them as “in press astro-ph/ .....” (number assigned by data base to that article)

Ph.D. Theses

- Basic structure of a Ph.D. thesis can follow two paths (Some Universities leave you no choice):
  - Path 1: Like a long research paper: IMRaD (possibly with multiple Results chapters)
  - Path 2: A succession of almost independent research papers bounded by an introduction and final conclusions
- In both cases the following parts are necessary:
  - Summary [language(s), form & length often prescribed by the university]
  - Introductory chapter: Review of the field, to show that the student has mastered the literature and background.
  - Conclusions chapter, including an outlook for future work. To show that the student has got his/her own ideas for future work & is ready for independent scientific work.

Ph.D. Theses

- Both IMPRS partner Universities allow paths 1 or 2. No need to rewrite the text of the papers (but you should reformat them)
- A Ph.D. thesis is longer than a typical research paper, i.e. there is more space for writing about details, specially about the methods
- Chapter(s) on methods and materials are obligatory only if Path 1 is followed, but are often also introduced for Path 2, since more space is available and you want to demonstrate that you understood what you were doing
- For path 1 the references are best listed at the end of the thesis, for path 2 after each chapter

Ph.D. Theses

- Questions can arise if there are multiple authors of a given paper forming a chapter of a thesis and in particular if the student is not the first author. Often a written statement from the student is required by the university pointing out his/her exact contribution.
- I tend to allow my students more freedom with individual style in the thesis than in papers. However, supervisors differ in this respect
- IMPORTANT! Your thesis MUST fulfill the formal requirements of the University (title page, summary, etc.). I have known theses to be turned down for purely formal reasons

Ph.D. Theses

- In the IMPRS we expect each Ph.D. thesis to contain the material of multiple research papers.
- Remember that your thesis will be carefully read by multiple people and you will be questioned about it. Don't take writing your thesis too lightly.
- Your marks can depend on how carefully you copy-edited your thesis (I know of outstanding students who missed getting a Summa for this very reason…)
- A thesis MUST satisfy the requirements of the university! Otherwise it might be rejected
- However, very few theses are read as often as research papers once the student has got his/her doctorate (although they are often given to new students starting on a subject as an introduction) Avoid unnecessary perfectionism

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- The lecture notes of Daniel Stotz on "Writing English for Science" was another great source of inspiration and material

- The article "This is not an article" by Carsten Sørensen is witty and provided me with ideas and material

- The same is true for the extensive and well-written guide by an unnamed author (or authors) at Bates College