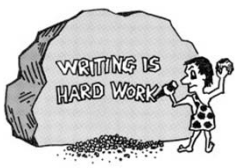
How to Write the Methods Section

Start with the "easiest" section

It is hard to face a blank page or screen, and the Methods are what you have been doing all along.

Thesis (or any research paper) structure:

I. Introduction and Background (often written last)
II. Methods
III. Results
IV. Discussion
V. Summary and/or Conclusions
VI. Future Work

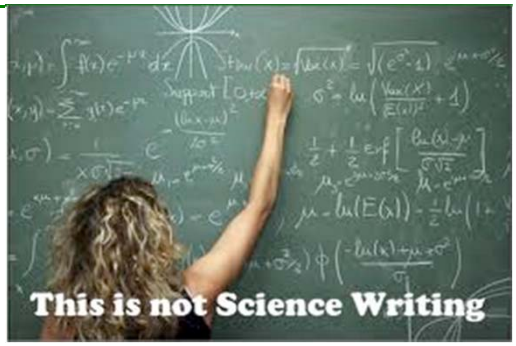


Methods Section

- It explicitly describes how the experiment or calculation was done
- It must be clear and precise
- Prose is usually straightforward
  - Simple explanation
  - In some cases say WHY you chose your methods
- Important for judging validity of results

What the Methods Section is Not!

- Results
- Discussion
- Summary/ Conclusions
- Future Work
- Introduction



It is a DESCRIPTION of HOW you did your work: Include NO results and NO discussion!

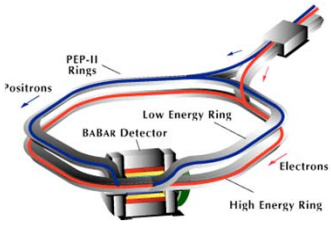
Getting Started

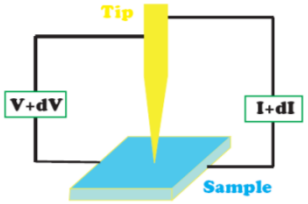
1. As always it starts with the outline
   - For new scientific writers, we strongly recommend outlining by paragraph – ideally a topic sentence for each
   - When you've written all sentences, you should consider revisions
2. So, how do I generate the outline: QUESTIONS
   - What do I have to do to reproduce the experiment or calculation?
   - What are the new or different techniques or ingredients or instrumentation?
   - What are the two or three best figures or diagrams to illustrate
     - The overall idea
     - The unique features

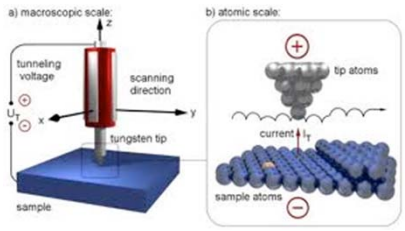
Getting Started

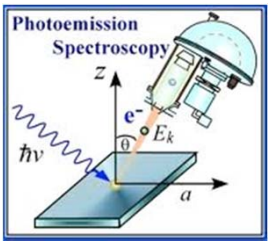
3. Aim for 4 pages, more or less – about 12 paragraphs (including space for figures)
   - Remember, one idea per paragraph

Figures can be Very Helpful



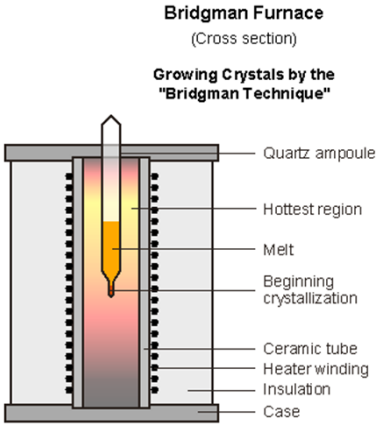






Note on Methods Figures

Helps others reproduce the experiment and decide if your results are valid – but no results!



Generally not – something special enough about the materials to spend a figure?

What to Include in Methods

- Describe the sequence of procedures, or research protocol
  - This is where you might need to describe why – and keep in mind the reader may not be familiar with this at all
- Explain exactly how preparations and measurements were made, or how calculations were performed
- Generally does *not* include techniques, tools or simulations used in analysis of data

Example

K. A. Sorathia, et al., Ap. J. 77 (2013) 21.

2. SIMULATIONS

The simulation code we employ is a contemporary translation (in Fortran-95) of the three-dimensional (3D) finite-difference MHD code *Zeus* (Stone & Norman 1992a, 1992b). The magnetic field is updated using the "method of characteristics constrained transport" algorithm to maintain zero divergence to machine accuracy (Hawley & Stone 1995). The *Zeus* code solves the standard equations of Newtonian fluid dynamics, but we augment its momentum equation with a term of the form $\rho \mathbf{v} \times \mathbf{h}$ to represent the gravitomagnetic force per unit mass, where ρ is the mass density, $\mathbf{v}$ is the fluid velocity, and

$$\mathbf{h} = \frac{2\mathbf{J}}{r^3} - \frac{6(\mathbf{J} \cdot \mathbf{r})\mathbf{r}}{r^5}. \quad (1)$$

Here $\mathbf{J}$ represents the magnitude and direction of the spin vector of the central mass and r is spherical radius.

In this paper we report two simulations, one employing full 3D MHD, but the other purely hydrodynamic so that we may identify the special properties due to MHD through contrasting the two. The initial condition for the MHD simulation is a

Example

C. Bernhard, B. Bessire, T. Freuer and A. Stefanov, Phys. Rev. A 88 (2013) 032322.

II. EXPERIMENTAL SETUP

Figure 1 depicts a schematic of the experimental setup. The entangled photons are generated in a type-0 SPDC process where all involved photons, the pump, the created idler (i), and signal (s), are identically polarized [25]. For this purpose we pump a 11.5-mm-long positive uniaxial and periodically poled nonlinear $KTiOPO_4$ (PPKTP) crystal with a poling periodicity of 9 μm by means of a quasimonochromatic $Nd:YVO_4$ (Coherent Verdi V5) laser centered at 532 nm featuring a narrow spectral bandwidth of about 5 MHz. The collinear pump beam is focused into the middle of the PPKTP crystal with a power of 5 W. To compensate for group-velocity dispersion in the setup and to allow for coherent shaping of the spectra, the idler and signal photon are imaged through a prism compressor arrangement composed of four N-SF 11 equilateral prisms, where the first prism deflects the residue of the pump into a beam dump. At the symmetry axis between the second and the third prism a SLM (Jenoptik, SLM-S640d) is aligned along the spatially dispersed down-converted spectrum. This device consists of two similar nematic liquid-crystal arrays of 640 pixels, each with a width of 100 μm and separated by a gap of 3 μm. The orientation of the liquid-crystal molecules within a pixel can be controlled by the applied voltage. Together with a linearly polarized input beam and a polarization-dependent detection scheme, the phase and amplitude of the transmitted frequencies at each pixel can be modulated. Coincidences of

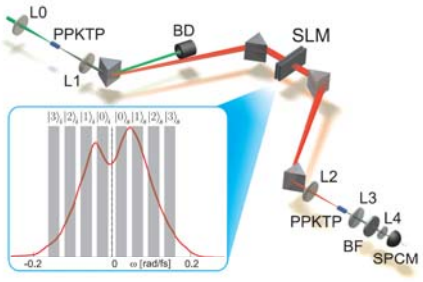


FIG. 1. (Color online) Schematic of the experimental setup and frequency-bin structure. L0, pump beam focusing lens (f = 150 mm); PPKTP, nonlinear crystal; BD, beam dump; SLM, spatial light modulator; L1 and L2, two-lens symmetric imaging arrangement (f = 100 mm) to enhance the spectral resolution with a magnification of 1:6 at the symmetry axis of the four-prisms compressor; BF, bandpass filter; SPCM, single-photon counting module with a two-lens (L3, L4) imaging system. The inset shows the measured down-converted spectrum overlaid with a schematic illustration of the frequency bins for a ququart. Each of the gray shaded areas represents a single bin whose amplitude and phase can be manipulated individually.

Final Notes

- Although this is the easiest section to write, it is the most important
- The Methods Section should stand on its own
  - even if you get few or no results, you can summarize your methods and then you have a strong "Future Work" section
- Put on your android hat and report – this is not the section for scientific creativity
- Once this is written, you have the basis for the flow and style of the rest of the thesis
  - easier for you to keep writing

Some References

- Richard H. Kallet, *"How to Write the Methods Section of a Research Paper"* Respiratory Care, **49**, 1229 (2004).
- How to write a paper in Scientific Journal and Format: http://abacus.bates.edu/~ganderso/biology/resources/writing/HTWsections.html
- Help with scientific writing: http://kmh-lanl.hansonhub.com/techwriting.html
- PhD Comics: http://www.phdcomics.com/