1869, Charles Joseph Minard

Figures

PHYS496 Fall 2017
Created by B. DeMarcro

Figures are part of the narrative

FIG. 3. Plan view of the pion/muon beamline. The pion decay channel is 80 m and the ring diameter is 14.1 m.

FIG. 2. Distribution of electron counts versus time for the 3.6×10^9 muon decays in the R01 μ^- data-taking period. The data is wrapped around modulo 100 μs.

- Each figure should have/make a single purpose/point
- Caption should explain every part of figure

1

Different types of figures

Explanatory

Results (Data) Figure

Explanatory Figure

Supercooled spin liquid state in the frustrated pyrochlore Dy₂Ti₂O₇

Ethan R. Kassner[a], Azar B. Eyvazov[a], Benjamin Pichler[a,b], Timothy J. S. Munsie[c,d], Hanna A. Dabkowska[c], Graeme M. Luke[c,d,e], and J. C. Séamus Davis[a,f,g,h,1]

Caption To Example Figure

Figure 1: Signatures of Supercooling in Classic Glass-forming Fluids

A. Under suitable conditions, a liquid can be cooled through the melting temperature T_m without crystallizing and instead reaches a supercooled liquid state. With further cooling, the heat capacity of the supercooled liquid must eventually decrease from the higher liquid value toward the lower crystalline value; this is necessary for the entropy to remain non-negative at very low temperatures. Supercooled liquids therefore typically have a broad peak in their heat capacity below T_m and a little above the glass transition temperature T_g.

B. In a classic supercooled liquid, diverging microscopic relaxation times $\tau_0(T)$ typically do not follow Arrhenius behavior (dashed line) but instead follow the Vogel-Tammann-Fulcher (VTF) evolution (blue curve; Eqn. 1). Here T_0 is a temperature at which the relaxation time diverges to ∞ while D characterizes the extent of the super-Arrhenius behavior. By convention, a classic glass is said to form when $\tau_0 > 100$s.

C. $Re[\varepsilon(\omega, T)]$ and $Im[\varepsilon(\omega, T)]$ of the Havriliak-Negami form (Eqn. 2) of the dielectric function; these are both characteristic of supercooled liquids.

D. Ultra-slow relaxation in glass-forming liquids occurs with a KWW form (green curve, Eqn. 3) instead of a Debye form (dashed line), as shown here for the dielectric function $\varepsilon(t)$.

Caption to Example Figure

Figure 2: Novel Experimental Techniques for Frustrated Magnetism in $Dy_2Ti_2O_7$

A. The Dy^{3+} moments (black circles) in $Dy_2Ti_2O_7$ are located on a lattice comprised of equilateral corner-sharing tetrahedra. The centers of tetrahedra themselves form a diamond lattice.

B. An allowed magnetic ground-state configuration for two tetrahedra in $Dy_2T_2iO_7$. Here the crystal field anisotropy causes the moments to point along their local [111] axes, thus forcing them to point toward or away from each tetrahedron center. To minimize magnetic energy, the spin configurations of a tetrahedron of $Dy_2T_2iO_7$ satisfy the spin equivalent of the Bernal-Fowler 'ice rules', with each tetrahedron having two spins pointing toward its center and two spins pointing away from its center.

C. Schematic of a pair of delocalized magnetic monopoles (+ green, - red) representing a sequence of spin flips as shown.

D. Schematic representation of the toroidal geometry of our $Dy_2Ti_2O_7$ sample (yellow) and the superconducting toroidal solenoid (blue). The cryogenic sample environment 30mK<T<4K is indicated by a dashed rectangle. DC current flow in the direction indicated by black arrow produces an azimuthal static magnetic field B_ϕ (blue arrows). If a fluid of magnetic-monopoles of both signs exists, the net magnetization current J_ϕ (red/green arrows) would be nonzero. Applied AC currents $I_0 Cos(\omega t)$ generate the azimuthal fields $H_\phi Cos(\omega t)$ whose effect is simultaneously detected by measuring the EMF across the STS: $V(\omega, T)$. The dynamical magnetic susceptibility components are then derived from $V_x(\omega, T) = -I_0 \omega L \chi''$, $V_y(\omega, T) = -I_0 \omega L \chi'$, where L is the effective geometrical inductance of the STS.

Explanatory Figure

- Gives overview, summary, or big picture
- Often schematic
- Not data or results
- Important to (over-) simplify without introducing errors
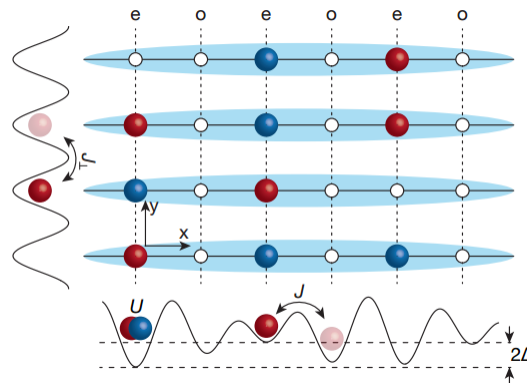- Important to be visually attractive

A great resource:

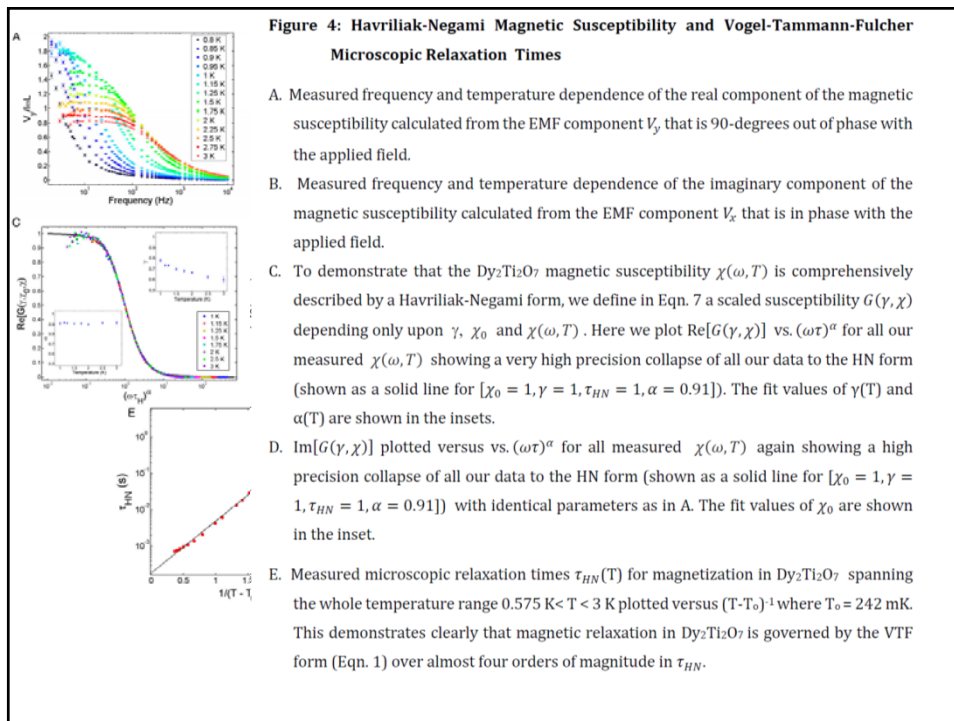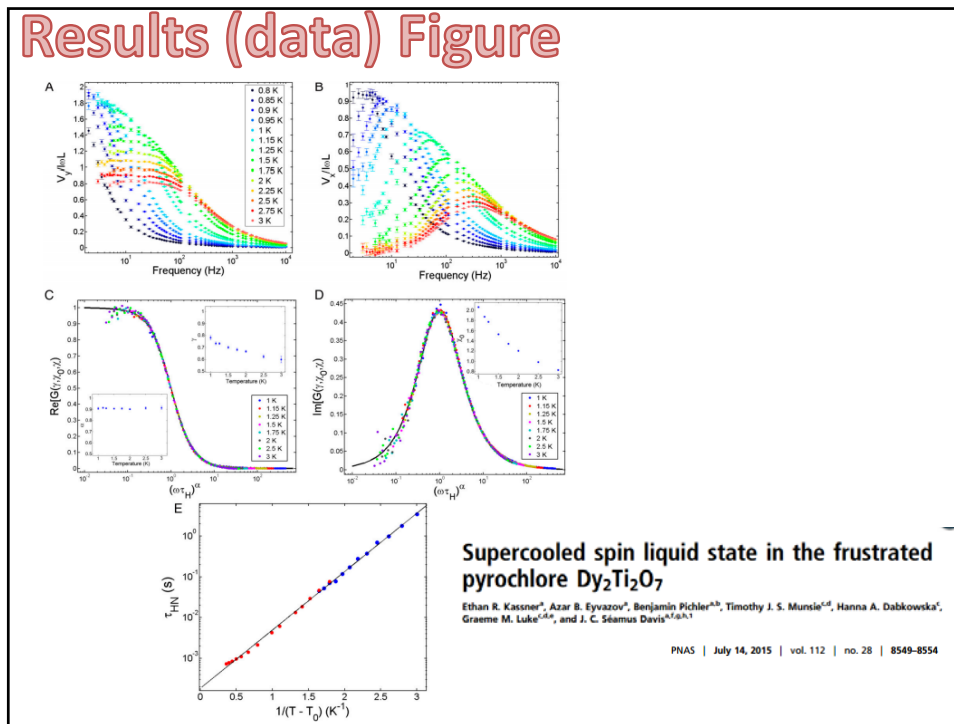Learn a software platform:
Illustrator, CorelDraw, Powerpoint…
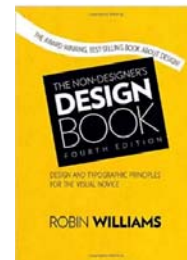
Example: Explanatory Figure

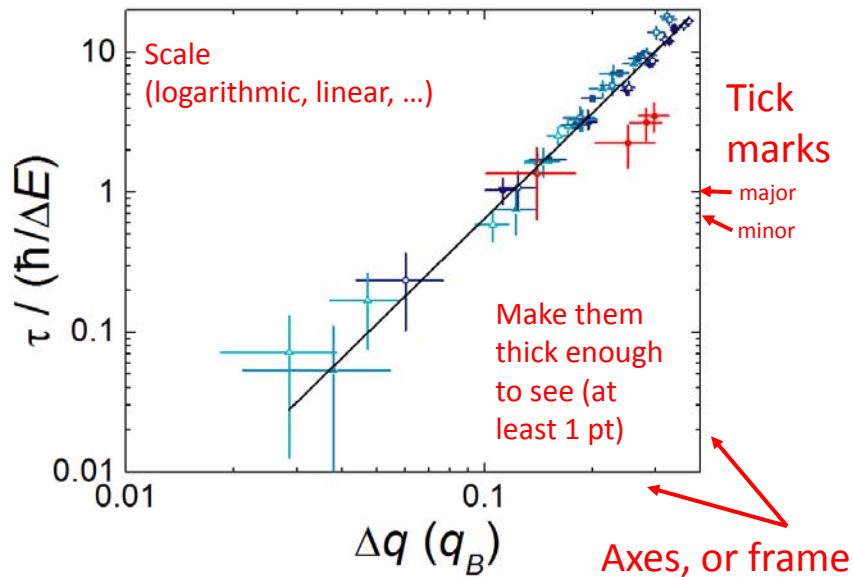**Coupling Identical**

Pranjal Bordia,[1,2] He
Michael Schreiber,[1,2] In

ar

FIG. 1. Coupling identical MBL systems: A charge density wave (CDW) with atoms only occupying even sites (e) is prepared in each of the identically disordered 1D tubes along the longitudinal (x) direction, with hopping J, on-site interaction energy U and disorder strength Δ. Red and blue spheres indicate a typical distribution of $|{\uparrow}\rangle$ and $|{\downarrow}\rangle$ atoms. We monitor the time evolution of such a state for different inter-tube coupling strengths $J_\perp$, that is different hopping amplitudes along the transverse (y) direction.
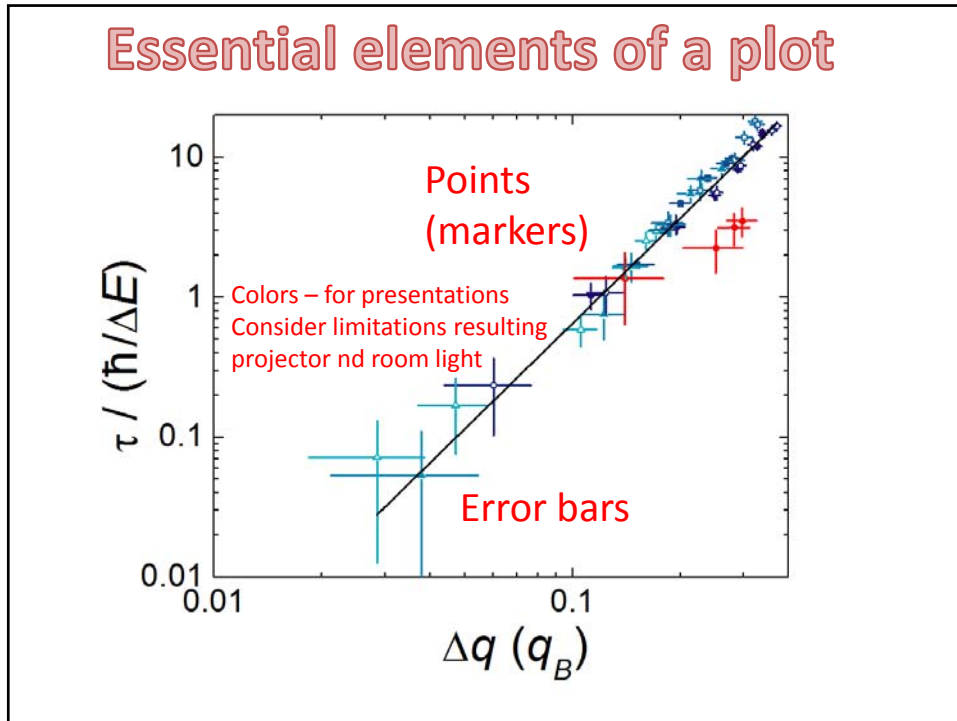
Results (data) Figure

Supercooled spin liquid state in the frustrated pyrochlore Dy₂Ti₂O₇

Ethan R. Kassner[a], Azar B. Eyvazov[a], Benjamin Pichler[a,b], Timothy J. S. Munsie[c,d], Hanna A. Dabkowska[e], Graeme M. Luke[c,d,e], and J. C. Séamus Davis[a,f,g,h,1]

Figure 4: Havriliak-Negami Magnetic Susceptibility and Vogel-Tammann-Fulcher Microscopic Relaxation Times

A. Measured frequency and temperature dependence of the real component of the magnetic susceptibility calculated from the EMF component V_y that is 90-degrees out of phase with the applied field.

B. Measured frequency and temperature dependence of the imaginary component of the magnetic susceptibility calculated from the EMF component V_x that is in phase with the applied field.

C. To demonstrate that the Dy₂Ti₂O₇ magnetic susceptibility $\chi(\omega,T)$ is comprehensively described by a Havriliak-Negami form, we define in Eqn. 7 a scaled susceptibility $G(\gamma,\chi)$ depending only upon γ, χ_0 and $\chi(\omega,T)$. Here we plot $\mathrm{Re}[G(\gamma,\chi)]$ vs. $(\omega\tau)^\alpha$ for all our measured $\chi(\omega,T)$ showing a very high precision collapse of all our data to the HN form (shown as a solid line for $[\chi_0 = 1, \gamma = 1, \tau_{HN} = 1, \alpha = 0.91]$). The fit values of $\gamma(T)$ and $\alpha(T)$ are shown in the insets.

D. $\mathrm{Im}[G(\gamma,\chi)]$ plotted versus vs. $(\omega\tau)^\alpha$ for all measured $\chi(\omega,T)$ again showing a high precision collapse of all our data to the HN form (shown as a solid line for $[\chi_0 = 1, \gamma = 1, \tau_{HN} = 1, \alpha = 0.91]$) with identical parameters as in A. The fit values of χ_0 are shown in the inset.

E. Measured microscopic relaxation times $\tau_{HN}(T)$ for magnetization in Dy₂Ti₂O₇ spanning the whole temperature range 0.575 K < T < 3 K plotted versus $(T-T_0)^{-1}$ where $T_0 = 242$ mK. This demonstrates clearly that magnetic relaxation in Dy₂Ti₂O₇ is governed by the VTF form (Eqn. 1) over almost four orders of magnitude in τ_{HN}.

Results (data) Figure

- Presents data, numerical results, theory curve
- Usually a graph
- Can encode a lot of information
    Be careful! Too much is deadly
- Important to label axes clearly and correctly
- Make sure points, lines, and error bars are visible and distinct

Essential elements of a plot

Essential elements of a plot

Points (markers)

Colors – for presentations
Consider limitations resulting
projector nd room light

Error bars

$\tau\,/\,(\hbar/\Delta E)$

$\Delta q\;(q_B)$

Essential elements of a plot

Thick enough to see!

curves

$\tau\,/\,(\hbar/\Delta E)$

$\Delta q\;(q_B)$

Essential elements of a plot

White space
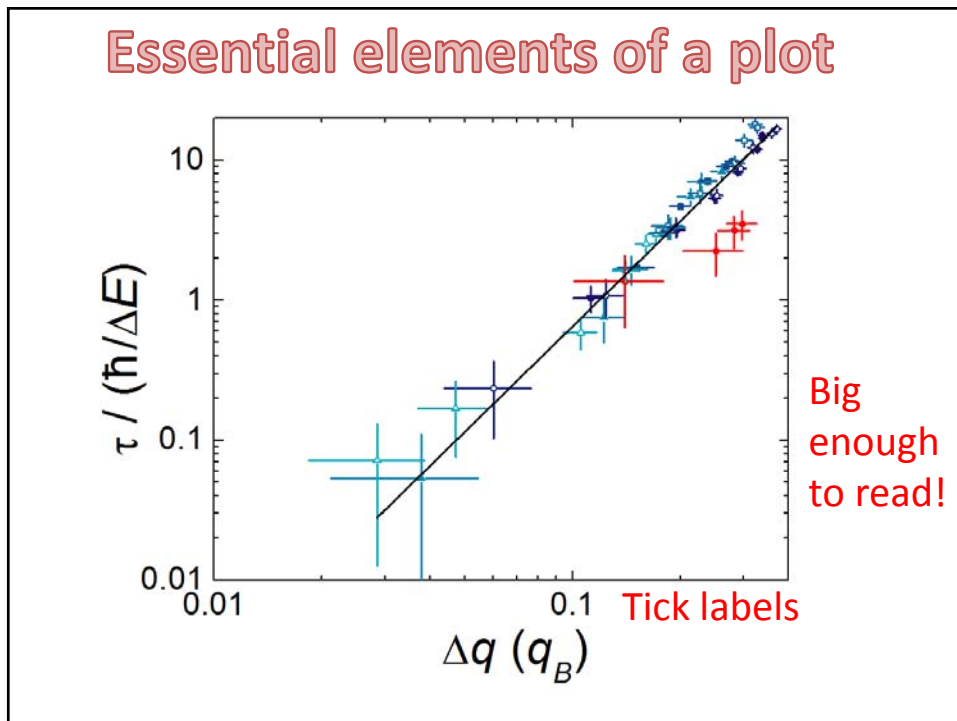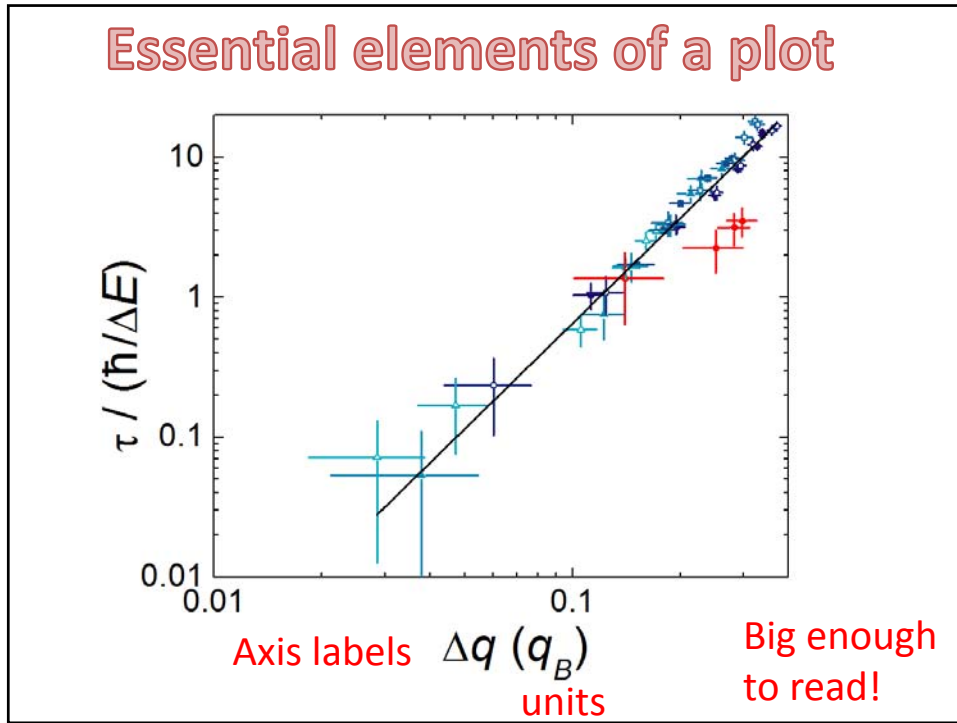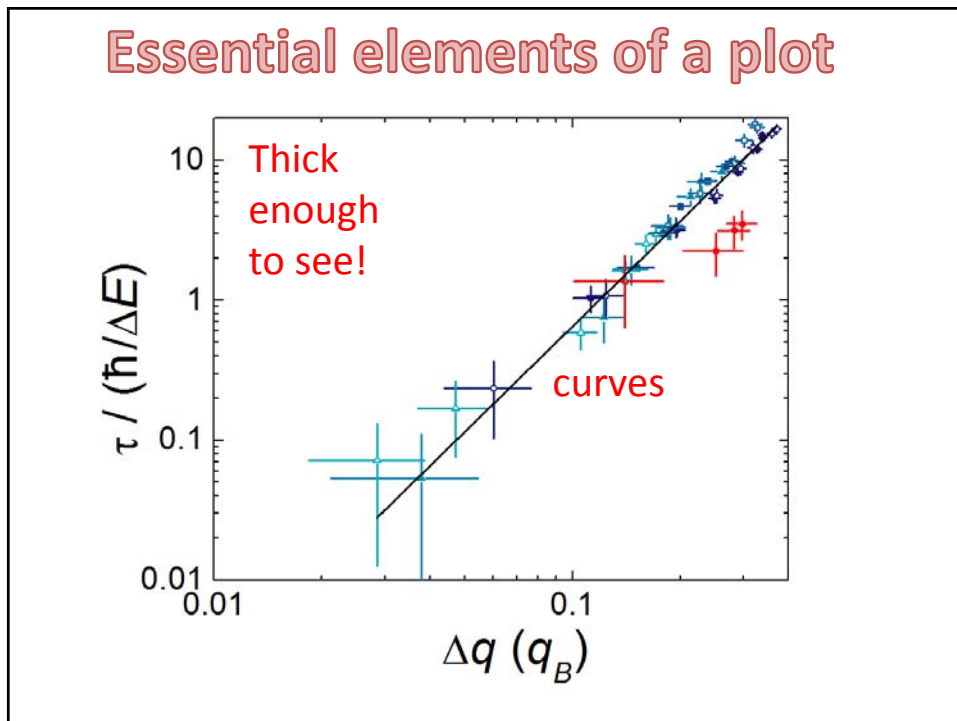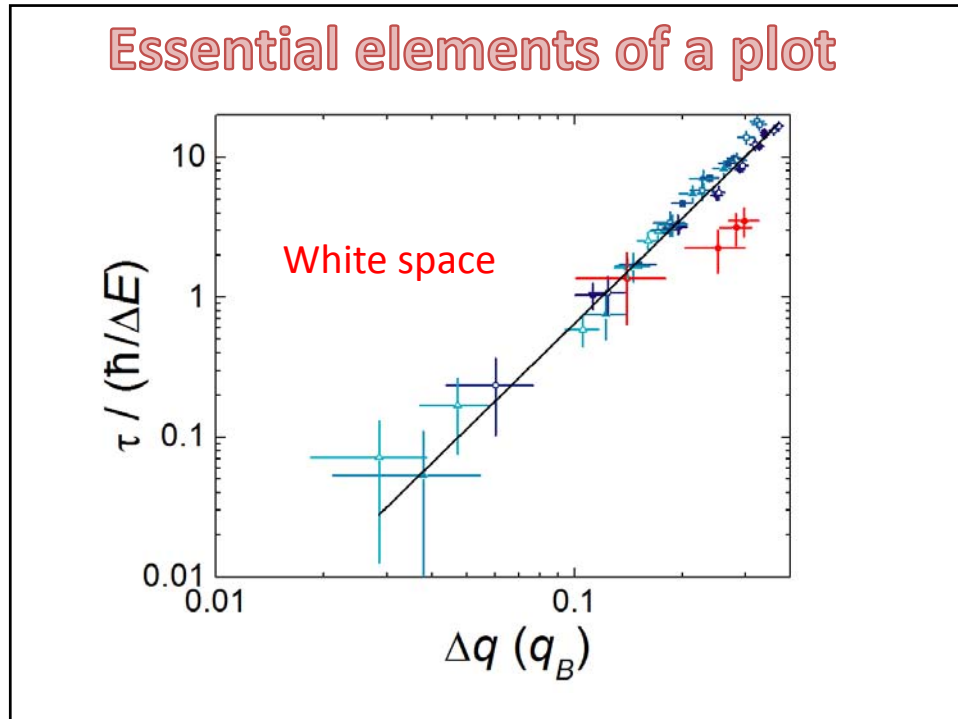
General Advice

- Legible fonts
  - Print the figure at 100% (reproduction scale)
  - Line thickness
- Avoid similar colors, yellow, orange
- Avoid arbitrary units
  - Use physical, standard units
- Explain every part of the figure in the caption
  - symbols, insets, what each part is about
- Include scale bars & color bars
- Use high resolution, high contrast images
- Use vector graphics when possible

Problems
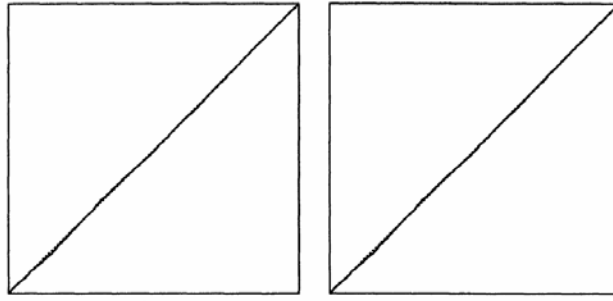
Figure 1. SRQ Plots of T_i/T_n (Vertical Axes) Against i/n (Horizontal Axes) for the Gibbs Sampler (a) and an Alternating Gibbs/Independence Sampler (b) for the Pump Failure Data Based on Runs of Length 5,000. Lines through the origin with unit slope are shown dashed; axis ranges are from 0 to 1 for all axes.

Problems
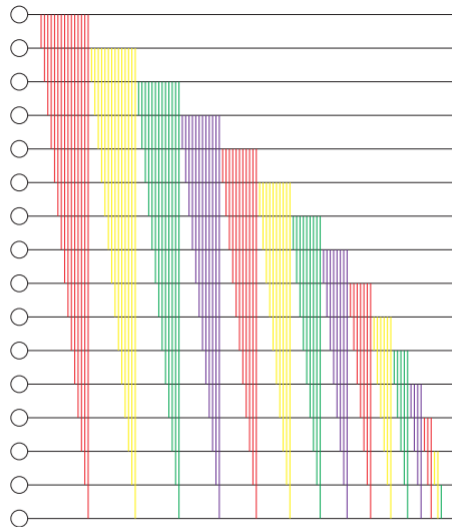
FIG. 2. (Color online) Possible layout for the 16-qubit chip.

Problems
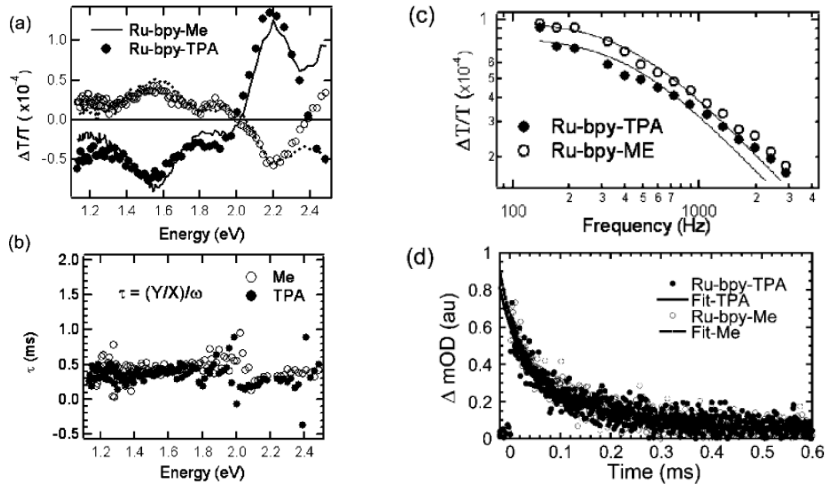
Resources

Software for making professional-quality plots

Origin (Webstore)
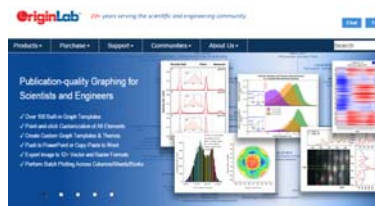
Matplotlib (Python)
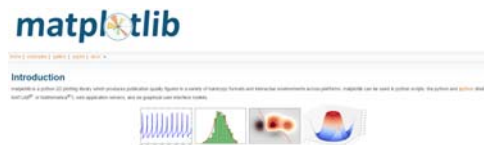
MATLAB, Mathematica…caution

ROOT

Resources

Software for making professional-quality figures

Line / vector art

Illustrator, CorelDraw, Inkscape (free)

Mathematica

3D Illustration

SketchUp (free), VPython (free), Blender (free)
Autodesk products (free for students)
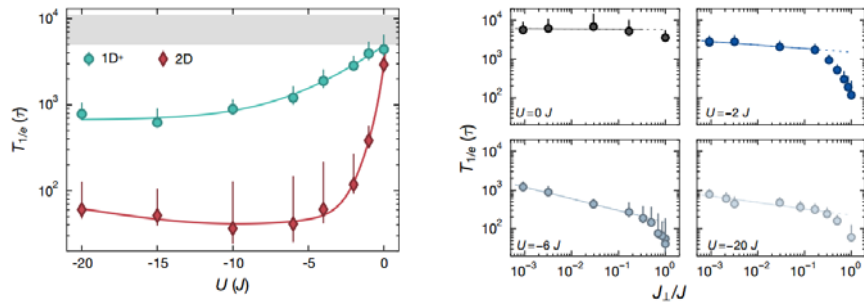
More resources (Celia)

Edward R. Tufte, *Visual Explanations: Images and Quantities, Evidence and Narrative* (Cheshire, CT, Graphics Press, 1997).

"Graphing Resources" (http://www.ncsu.edu/labwrite/res/res-homepage.htm), particularly their "Revising your Visuals" section.

Another example: results figure

Coupling Identical 1D Many-Body Localized Systems

Pranjal Bordia,[1,2] Henrik P. Lüschen,[1,2] Sean S. Hodgman,[1,2]
Michael Schreiber,[1,2] Immanuel Bloch,[1,2] and Ulrich Schneider[1,2,3]

arXiv:1509.00478v1