Physics 496
Introduction to Research

Lecture 6.0: Scientific Ethics

DHB with CME, Tony Liss, Dave Hertzog, Lance Cooper

Why ethics matters

"In the cathedral of science, every brick is equally important."

—Max Delbrück
Nobel Laureate, 1969

From the APS

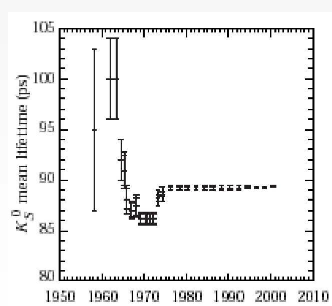
Each physicist is a citizen of the community of science. Each shares responsibility for the welfare of this community.

http://www.aps.org/statements/02.2.html

Scientific progress relies on …

- Truthfulness and full disclosure
- Accurate and complete record-keeping
- Free and open exchange of data and interpretations
- Skepticism

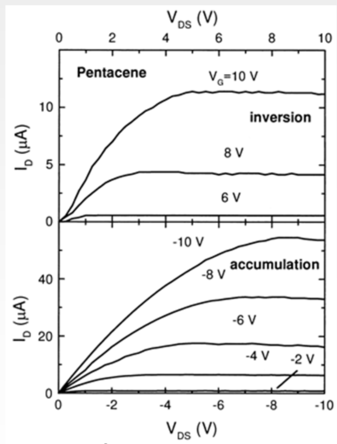
…but honest error is inevitable



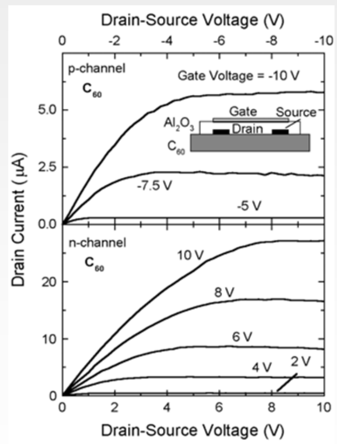
Everyone* recognizes that deliberate dishonesty is wrong

- Forged or fabricated data
- Falsified or invented results

*Well, *practically* everyone…



J. H. Schön, et al., Ambipolar Pentacene Field-Effect Transistors and Inverters," *Science* **287**, 1022 (2000).



J. H. Schön, et al., "A Superconducting Field Effect Switch," *Science* **288**, 656 (2000).

Not all ethics situations are so clear

Referencing and using scholarly work

Data selection and interpretation

Intellectual property "ownership"

Authorship

Plagiarism is another form of scientific dishonesty

Submitting another's published or unpublished work, in whole, in part, or in paraphrase, as one's own without properly crediting the author by footnotes, citations, or bibliographical reference.

Submitting material obtained from an individual or agency as one's own original work without reference to the person or agency as the source of the material.

Submitting material that has been produced through unacknowledged collaboration with others as one's own original work without written release from collaborators.

Plagiarism: Case Study

While classical melting in two-dimensional systems is reminiscent of the phase behavior observed as a function of pressure in this material, an important qualification should be made with respect to this comparison. In contrast to the examples described above, the melting process observed in *1T*-$TiSe_2$ is quantum mechanical in nature, in that it is driven near $T = 0$ K by pressure tuning the competing interactions in this system. To understand the nature of this competition, note first that the zero-pressure charge density wave (CDW) state in *1T*-$TiSe_2$ is unconventional, as it arises from an indirect Jahn-Teller interaction that splits and lowers the unoccupied conduction band. As a result of the electron-hole interaction between the conduction and valence bands, the lowering of the split conduction band "repulses" and flattens the valence band, resulting in a lowering of the system's energy, and the formation of a small gap CDW state.

From: C.S. Snow et al., Phys. Rev. Lett. 91, 136402 (2003)

Original:

While classical melting in two-dimensional systems is reminiscent of the phase behavior observed as a function of pressure in this material, an important qualification should be made with respect to this comparison.

In contrast to the examples described above, the melting process observed in *1T*-$TiSe_2$ is quantum mechanical in nature, in that it is driven near $T = 0$ K by pressure tuning the competing interactions in this system.

To understand the nature of this competition, note first that the zero-pressure charge density wave (CDW) state in *1T*-$TiSe_2$ is unconventional, as it arises from an indirect Jahn-Teller interaction that splits and lowers the unoccupied conduction band.

Edited:

The phase behavior observed as a function of pressure in *1T*-$TiSe_2$ is similar to classical melting in 2D materials.

However, in contrast to classical melting, the melting process seen in *1T*-$TiSe_2$ is governed by quantum mechanics, as it is the result of tuning the competing quantum mechanical interactions with pressure near $T = 0$ K.

An examination of the unconventional charge density wave (CDW) in *1T*-$TiSe_2$ state helps elucidate this competition—the CDW state in *1T*-$TiSe_2$ is caused by an indirect Jahn-Teller interaction that lowers the unoccupied conduction band relative to the filled valence

All sentences are changed and the passage is reorganized!!

Is this an example of plagiarism?

YES IT IS!

- **Although the words and ordering have been altered, the essential meaning remains the same**
- **Credit has not been given to the original author of these ideas**

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Avoiding Plagirism*

If you are summarizing the work of others, citing the work(s) is the key.

Write without the work you are summarizing in front of you. Use your own words.

If you need direct quotes, make sure they are used within quotation marks.

Some judgment is needed if you are repeating commonly used phraseology. For instance, in the previous example "an indirect Jahn-Teller interaction" can probably be used without quotation marks.

Cite the source, cite the source, cite the source.

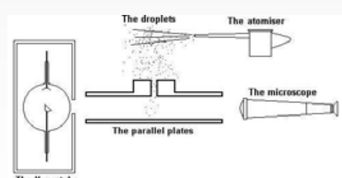
See what I did here? ⟶ (adapted from "Lance Cooper's tips", 2010)

Although data falsification or fabrication is clearly wrong, what about more-subtle data "selection"?

Example: In 1909, Millikan measured the charge *e* of the electron in his famous "oil drop" experiment … there have been raging scholarly debates since then about his use of "selected" drops, given his claim that *all* drops were included in his published results

- **Too bad there remains a kind of doubt hanging over it**
- **An important and highly scrutinized result (Nobel Prize),**
- **We won't debate that here, but you can read about it here**

In science, it is generally accepted that certain data may be rejected, but under what conditions?



Reality of the experimental method—things go wrong; equipment malfunctions and people make mistakes

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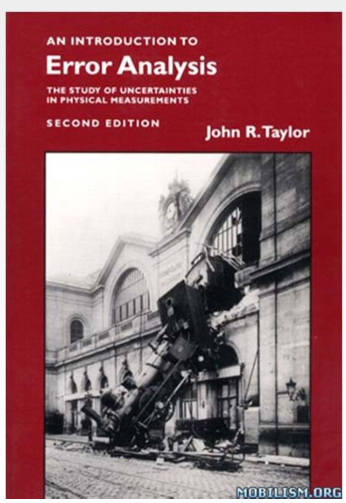
Data may be excluded for sound reasons but must be disclosed

- Use accepted statistical tests
  - Chauvenet's criterion§: the outlier is more than $t\sigma$ from the mean of N measurements
  - Kolmogorov-Smirnov tests, designed to compare runs against a standard data set in a result-independent manner
- Decide *before* the *experiment* what your criteria are for accepting or excluding data
  - Avoid bias (literally: prejudice)
- More difficult … after the experiment you discover biases based on something you monitored but you did not "pre-reject" data. Now what?
  - Some of this can be avoided by a well-designed *blind* analysis.

§ J.R. Taylor, *An Introduction to Error Analysis* (Mill Valley CA, University Science Books, 1982).

Best cover ever



Authorship should be limited to those who contributed *meaningfully* to the concept, design, execution, or analysis of the work

- Each person who contributed to the work should be offered authorship
- Credit should always be given for others' work
- Every co-author should have an opportunity to examine a manuscript prior to publication
- Each author is obligated to promptly disclose errors and provide corrections for published work

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Coauthors and collaborators share responsibility for published work

- Some coauthors are responsible for accuracy and verifiability of the *entire paper*
  - *Built the apparatus, recorded the data, analyzed the data, supervised junior researchers, wrote the paper*
- Coauthors who make specific, limited contributions may have only limited responsibility
  - *Fabricated the thin films that others tested*
- All collaborations should have a process for reviewing and ensuring the accuracy and validity of reported results
- Anyone unwilling or unable to accept appropriate responsibility for a paper should not be a coauthor

There are some very difficult issues with authorship in very large collaborations.

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Physics Letters B

www.elsevier.com/locate/physletb

Observation of a new particle in the search for the Standard Model Higgs boson with the ATLAS detector at the LHC ☆

ATLAS Collaboration *

This paper is dedicated to the memory of our ATLAS colleagues who did not live to see the full impact and significance of their contributions to the experiment.

A R T I C L E   I N F O

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A B S T R A C T

A search for the Standard Model Higgs boson in proton–proton collisions with the ATLAS detector at the LHC is presented. The datasets used correspond to integrated luminosities of approximately 4.8 fb^{-1} collected at $\sqrt{s} = 7$ TeV in 2011 and 5.8 fb^{-1} at $\sqrt{s} = 8$ TeV in 2012. Individual searches in the channels $H \to ZZ^{(*)} \to 4\ell$, $H \to \gamma\gamma$ and $H \to WW^{(*)} \to e\nu\mu\nu$ in the 8 TeV data are combined with previously published results of searches for $H \to ZZ^{(*)}$, $WW^{(*)}$, $b\bar{b}$ and $\tau^+\tau^-$ in the 7 TeV data and results from improved analyses of the $H \to ZZ^{(*)} \to 4\ell$ and $H \to \gamma\gamma$ channels in the 7 TeV data. Clear evidence for the production of a neutral boson with a measured mass of 126.0 ± 0.4 (stat) ± 0.4 (sys) GeV is presented. This observation, which has a significance of 5.9 standard deviations, corresponding to a background fluctuation probability of 1.7×10^{-9}, is compatible with the production and decay of the Standard Model Higgs boson.

1. Introduction

The Standard Model (SM) of particle physics [1–4] has been tested by many experiments over the last four decades and has been shown to successfully describe high energy particle interactions. However, the mechanism that breaks electroweak symmetry in the SM has not been verified experimentally. This mechanism [5–10] which gives mass to massive elementary particles, implies

120–135 GeV; using the existing LHC constraints, the observed local significances for $m_H = 125$ GeV are 2.7σ for CDF [14], 1.1σ for DØ [15] and 2.8σ for their combination [16].

The previous ATLAS searches in 4.6–4.8 fb^{-1} of data at $\sqrt{s} = 7$ TeV are combined here with new searches for $H \to ZZ^{(*)} \to 4\ell$,[1] $H \to \gamma\gamma$ and $H \to WW^{(*)} \to e\nu\mu\nu$ in the 5.8–5.9 fb^{-1} of pp collision data taken at $\sqrt{s} = 8$ TeV between April and June 2012.

The data were recorded with instantaneous luminosities up to

ATLAS Collaboration

G. Aad [48], T. Abajyan [21], B. Abbott [111], J. Abdallah [12], S. Abdel Khalek [115], A.A. Abdelalim [49], O. Abdinov [11], R. Aben [105], B. Abi [112], M. Abolins [88], O.S. AbouZeid [158], H. Abramowicz [153], H. Abreu [136], B.S. Acharya [164a,164b], L. Adamczyk [38], D.L. Adams [25], T.N. Addy [56], J. Adelman [176], S. Adomeit [98], P. Adragna [75], T. Adye [129], S. Aefsky [23], J.A. Aguilar-Saavedra [124b,a], M. Agustoni [17], M. Aharrouche [81], S.P. Ahlen [22], F. Ahles [48], A. Ahmad [148], M. Ahsan [41], G. Aielli [133a,133b], T. Akdogan [19a], T.P.A. Åkesson [79], G. Akimoto [155], A.V. Akimov [94], M.S. Alam [2], M.A. Alam [76], J. Albert [169], S. Albrand [55], M. Aleksa [30], I.N. Aleksandrov [64], F. Alessandria [89a], C. Alexa [26a], G. Alexander [153], G. Alexandre [49], T. Alexopoulos [10], M. Alhroob [164a,164c], M. Aliev [16], G. Alimonti [89a], J. Alison [120], B.M.M. Allbrooke [18], P.P. Allport [73], S.E. Allwood-Spiers [53], J. Almond [82], A. Aloisio [102a,102b], R. Alon [172], A. Alonso [79], F. Alonso [70], A. Altheimer [35], B. Alvarez Gonzalez [88], M.G. Alviggi [102a,102b], K. Amako [65], C. Amelung [23], V.V. Ammosov [128,*], S.P. Amor Dos Santos [124a], A. Amorim [124a,b], N. Amram [153], C. Anastopoulos [30], L.S. Ancu [17], N. Andari [115], T. Andeen [35], C.F. Anders [58b], G. Anders [58a], K.J. Anderson [31], A. Andreazza [89a,89b], V. Andrei [58a], M.-L. Andrieux [55], X.S. Anduaga [70], S. Angelidakis [9], P. Anger [44], A. Angerami [35], F. Anghinolfi [30], A. Anisenkov [107], N. Anjos [124a], A. Annovi [47], A. Antonaki [9], M. Antonelli [47], A. Antonov [96], J. Antos [144b], F. Anulli [132a], M. Aoki [101], S. Aoun [83], L. Aperio Bella [5], R. Apolle [118,c], G. Arabidze [88], I. Aracena [143], Y. Arai [65], A.T.H. Arce [45], S. Arfaoui [148], J.-F. Arguin [93], E. Arik [19a,*], M. Arik [19a], A.J. Armbruster [87], O. Arnaez [81], V. Arnal [80], C. Arnault [115], A. Artamonov [95], G. Artoni [132a,132b], D. Arutinov [21], S. Asai [155], S. Ask [28], B. Åsman [146a,146b], L. Asquith [6], K. Assamagan [25], A. Astbury [169], M. Atkinson [165], B. Aubert [5], E. Auge [115], K. Augsten [127], M. Aurousseau [145a], G. Avolio [163], R. Avramidou [10], D. Axen [168], G. Azuelos [93,d], Y. Azuma [155], M.A. Baak [30], G. Baccaglioni [89a], C. Bacci [134a,134b], A.M. Bach [15], H. Bachacou [136], K. Bachas [30], M. Backes [49], M. Backhaus [21], J. Backus Mayes [143], E. Badescu [26a], P. Bagnaia [132a,132b], S. Bahinipati [3], Y. Bai [33a], D.C. Bailey [158], T. Bain [158], J.T. Baines [129], O.K. Baker [176], M.D. Baker [25], S. Baker [77], P. Balek [126], E. Banas [39], P. Banerjee [93], Sw. Banerjee [173], D. Banfi [30], A. Bangert [150], V. Bansal [169], H.S. Bansil [18], L. Barak [172], S.P. Baranov [94], A. Barbaro Galtieri [15], T. Barber [48], E.L. Barberio [86], D. Barberis [50a,50b], M. Barbero [21], D.Y. Bardin [64], T. Barillari [99], M. Barisonzi [175], T. Barklow [143], N. Barlow [28], B.M. Barnett [129], R.M. Barnett [15], A. Baroncelli [134a], G. Barone [49], A.J. Barr [118], F. Barreiro [80], J. Barreiro Guimarães da Costa [57], P. Barrillon [115], R. Bartoldus [143], A.E. Barton [71], V. Bartsch [149], A. Basye [165], R.L. Bates [53], L. Batkova [144a], J.R. Batley [28], A. Battaglia [17], M. Battistin [30], F. Bauer [136], H.S. Bawa [143,e], S. Beale [98], T. Beau [78], P.H. Beauchemin [161], R. Beccherle [50a], P. Bechtle [21], H.P. Beck [17], A.K. Becker [175], S. Becker [98], M. Beckingham [138], K.H. Becks [175], A.J. Beddall [19c], A. Beddall [19c], S. Bedikian [176], V.A. Bednyakov [64], C.P. Bee [83], L.J. Beemster [105], M. Begel [25], S. Behar Harpaz [152], P.K. Behera [62], M. Beimforde [99],

+9 more pages

Many ethics resources are available

- National Center for Professional and Research Ethics
  http://ethicscenter.csl.illinois.edu/
- Online Ethics Center for Engineering and Science
  http://onlineethics.org/
- Applied Ethics “Case of the Month” Club
  http://www.niee.org/case-of-the-month/
- Engineering Ethics
  http://repo-nt.tcc.virginia.edu/ethics/
- *Fundamentals of Ethics for Scientists and Engineers*, E.G. Seebauer and R.L. Barry (Oxford, Oxford University Press, 2000).
- *On Being a Scientist: Responsible Conduct in Research*, 2nd ed., NAS Press
  http://www.nap.edu/readingroom/books/obas/

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