RESEARCH METHODOLOGY

AUTUMN SEMESTER, 2021

AMITABHA LAHIRI

S. N. BOSE NATIONAL CENTRE FOR BASIC SCIENCES

LECTURE N 17-11-2021

Types of scientific writing (and readership)

- Papers (Journal articles)
  - Report of research
  - Size of readership depends on the quality, importance, immediacy …
  - Writing for reviewers …
- Review articles
  - Usually wide readership
  - Often invited
- Theses
  - Usually only read by reviewers
- Other (Grant proposals, science journalism, equipment description …)

Structure of a typical paper

- Title (what is in the paper)
- **Author(s) (+ affiliation)**
- **Abstract**
- **Introduction/Background**
- Description/Methods/Calculations
- Results
- Discussions/Conclusions
- Acknowledgements
- Bibliography/References
- Appendices (optional)

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MEASURING DISTANCE AND PROPERTIES OF THE MILKY WAY'S CENTRAL SUPERMASSIVE BLACK HOLE WITH STELLAR ORBITS

A. M. GHEZ,[1,2] S. SALIM,[1,3] N. N. WEINBERG,[4,5] J. R. LU,[1] T. DO,[1] J. K. DUNN,[1] K. MATTHEWS,[4] M. R. MORRIS,[1] S. YELDA,[1] E. E. BECKLIN,[1] T. KREMENEK,[1] M. MILOSAVLJEVIC,[6] AND J. NAIMAN[1,7]
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ABSTRACT

We report new precision measurements of the properties of our Galaxy's supermassive black hole. Based on astrometric (1995–2007) and radial velocity (RV; 2000–2007) measurements from the W. M. Keck 10 m telescopes, a fully unconstrained Keplerian orbit for the short-period star S0-2 provides values for the distance (R_0) of 8.0 ± 0.6 kpc, the enclosed mass ($M_{\rm bh}$) of $4.1 \pm 0.6 \times 10^6\ M_\odot$, and the black hole's RV, which is consistent with zero with 30 km s^{-1} uncertainty. If the black hole is assumed to be at rest with respect to the Galaxy (e.g., has no massive companion to induce motion), we can further constrain the fit, obtaining $R_0 = 8.4 \pm 0.4$ kpc and $M_{\rm bh} = 4.5 \pm 0.4 \times 10^6\ M_\odot$. More complex models constrain the extended dark mass distribution to be less than $3–4 \times 10^5\ M_\odot$ within 0.01 pc, ~100 times higher than predictions from stellar and stellar remnant models. For all models, we identify transient astrometric shifts from source confusion (up to 5 times the astrometric error) and the assumptions regarding the black hole's radial motion as previously unrecognized limitations on orbital accuracy and the usefulness of fainter stars. Future astrometric and RV observations will remedy these effects. Our estimates of R_0 and the Galaxy's local rotation speed, which it is derived from combining R_0 with the apparent proper motion of Sgr A*, ($\theta_0 = 229 \pm 18$ km s^{-1}), are compatible with measurements made using other methods. The increased black hole mass found in this study, compared to that determined using projected mass estimators, implies a longer period for the innermost stable orbit, longer resonant relaxation timescales for stars in the vicinity of the black hole and a better agreement with the $M_{\rm bh}$-σ relation.

Subject headings: black hole physics — Galaxy: center — Galaxy: kinematics and dynamics — infrared: stars — techniques: high angular resolution

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A programmable dual RNA-guided DNA endonuclease in adaptive bacterial immunity

Martin Jinek[#1,2], **Krzysztof Chylinski**[#3,4], **Ines Fonfara**[4], **Michael Hauer**[2,5], **Jennifer A. Doudna**[1,2,6,7,*], and **Emmanuelle Charpentier**[4,*]

[1]Howard Hughes Medical Institute, University of California, Berkeley, California 94720, USA. [2]Department of Molecular and Cell Biology, University of California, Berkeley, California 94720, USA. [3]Max F. Perutz Laboratories, University of Vienna, A-1030 Vienna, Austria. [4]The Laboratory for Molecular Infection Medicine Sweden (MIMS), Umeå Centre for Microbial Research (UCMR), Department of Molecular Biology, Umeå University, S-90187 Umeå, Sweden. [5]Present address: Friedrich Miescher Institute for Biomedical Research, 4058 Basel, Switzerland. [6]Department of Chemistry, University of California, Berkeley, California 94720, USA. [7]Physical Biosciences Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA.

[#] These authors contributed equally to this work.

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MEASUREMENT OF THE SOLAR ELECTRON NEUTRINO FLUX WITH THE HOMESTAKE CHLORINE DETECTOR

BRUCE T. CLEVELAND, TIMOTHY DAILY, RAYMOND DAVIS, JR., JAMES R. DISTEL, KENNETH LANDE,[1]
C. K. LEE, AND PAUL S. WILDENHAIN
Department of Physics and Astronomy, University of Pennsylvania, 209 South 33rd Street, Philadelphia, PA 19104

AND

JACK ULLMAN
Department of Physics and Astronomy, Herbert Lehman College (City University of New York), 250 Bedford Park Boulevard West, Bronx, NY 10468
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ABSTRACT

The Homestake Solar Neutrino Detector, based on the inverse beta-decay reaction $\nu_e + {}^{37}\mathrm{Cl} \rightarrow {}^{37}\mathrm{Ar} + e^-$, has been measuring the flux of solar neutrinos since 1970. The experiment has operated in a stable manner throughout this time period. All aspects of this detector are reviewed, with particular emphasis on the determination of the extraction and counting efficiencies, the key experimental parameters that are necessary to convert the measured ^{37}Ar count rate to the solar neutrino production rate. A thorough consideration is also given to the systematics of the detector, including the measurement of the extraction and counting efficiencies and the nonsolar production of ^{37}Ar. The combined result of 108 extractions is a solar neutrino–induced ^{37}Ar production rate of 2.56 ± 0.16 (statistical) $\pm$ 0.16 (systematic) SNU.
Subject headings: elementary particles — Sun: interior — Sun: particle emission

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Facilities: Keck:II (NIRC2, NIRSPEC, OSIRIS), Keck:I (NIRC)

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Some comments on references

- Previous works on the problem
  - Related to work/motivation/background
  - Has helped in the work or writing
  - Published/unpublished
- At the end (before or after Appendices)
- Second most important part (after the actual work)
  - Arises mostly out of the introduction
  - People like to be cited: a referee may get upset for not being cited
  - Not a good idea to fill with unnecessary references to a possible referee