Report for Pepijn van Erp et al.

Santilli Telescope Design, Operation and Reported Results

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I. CREDENTIALS AND EXPERIENCE: MARIA P. WOMACK, Ph.D.

1. My education includes a Bachelor's degree in Physics from Florida State University, and a Ph.D. in Physics from Arizona State University in Tempe, AZ (1991).

2. My curriculum vitae (copy attached) has complete details of my professional experience, which I summarize here. From 1992 to 1994 I held a full-time postdoctoral research position at the Northern Arizona University Department of Physics and Astronomy. From 1994 to 2015 I held full-time tenure-track faculty positions: first at Pennsylvania State University at Erie, and then at St. Cloud State University. I was granted tenure at SCSU in 2000, and promoted to full professor in 2005. I taught physics and astronomy courses at all levels, including an upper level course titled "Observational Astronomy." I maintained an active research laboratory, built and managed the SCSU Observatory, mentored undergraduate and graduate research students, and performed university and community service. During 2011-2015 I was reassigned to the National Science Foundation (NSF) Division of Astronomical Sciences in Arlington, Virginia, where I served as Program Director. My NSF responsibilities included managing a $20 Million annual budget, creating and developing the joint NASA-NSF telescope partnership "NN-EXPLORE." I identified and evaluated potentially transformative research, made funding recommendations based on merit review, and provided evaluation and oversight of funded programs. I also worked with colleagues to prepare and present astronomical information to staffers and testimony for hearings of U.S. House of Representatives Science, Space and Technology Committee. Since August 2015 I have been employed by the University of South Florida (USF) in Tampa, FL in a part-time position as Research Professor, and hired by NSF as part-time expert consultant. My responsibilities at USF include mentoring graduate and undergraduate research students, university and community service, and maintaining an active research program. My research laboratory personnel currently include two Ph.D.-seeking graduate students. My research focuses on observational astrophysics using ground- and space-based telescopes at optical, infrared and millimeter wavelengths.

3. I am the author of over 25 peer-reviewed publications (listed on my curriculum vitae), over 600 technical review analysis reports, and have been an invited speaker on astronomical research and federal funding over 25 times across the U.S. and in Germany. I have reviewed for many funding agencies and scientific journals, awarded over $1 million in grant funding from NSF and NASA, and awarded telescope access time with an estimated value of over $2 million at national and international facilities, including Keck Observatory in Hawaii, Kepler K2 space-telescope, Arizona Radio Observatory, Institut de Radioastronomie Millimetrique 30-m telescope in Spain, National Radio Astronomical Observatory, and Caltech Submillimeter Observatory in Hawaii.

4. I have been retained by the firm of Thomas & LoCicero and asked to provide an expert opinion regarding the Santilli telescope and comments made about it. My expertise was sought in the areas of observational astronomy, telescope use, astrophysics, and antimatter. During the past four years, I have not testified as an expert at trial or by deposition. I am being compensated for my study at a rate of $400/hour and testimony at a rate of $800/hour.

II. OVERVIEW

This report addresses the claims made about the so-called Santilli telescope. It includes a discussion and evaluation of telescope optics, antimatter, and research standards appropriate for data acquisition, reduction, analysis, and publication.

III. MATERIAL REVIEWED

a. Complaint with Exhibit A
b. Video Van000419.mpr emailed by Mr. Lake on Mar 28, 2018, Tallahassee Entity 2016
c. Two blogs about Science Publishing Group emailed by Mr. Lake on Mar 28, 2018
d. Invoices and price lists for Galileo-Santilli Telescope System emailed by Mr. Lake on Mar 28, 2018
e. Notebook of material provided to me by Mr. Lake on Feb 13, 2018, containing
    1. Pepijn van Erp article dated February 6, 2016
    2. Transcript of "Thunder Energies Discovers Invisible Entities" where Santilli and Gaines describe telescope operation and results, found at this video link: https://www.youtube.com/watch?v=_gRC2q_VLEM
    3. Thunder Energies Corporation: TEC Division of Optical Equipment (TEC-DOE) "Detection of Antimatter Galaxies, Asteroids and Cosmic Rays"
    4. "Apparent Detection via New Telescopes with Concave Lenses of Otherwise Invisible Terrestrial Entities (ITE), American Journal of Modern Physics 2016
    5. "Apparent Detection of Antimatter Galaxies via a Refractive Telescope with Concave Lenses," Clifford Analysis, Clifford Algebras and their Applications 2014
    6. Cease & Desist letter to Dr. Frank Israel from Joseph E. Parrish on behalf of Ruggero Santilli dated May 20, 2016
    7. Response letter to Joseph E. Parrish from Dr. Jan Willem Nienhuys, dated June 17, 2016

I asked to inspect a Santilli telescope, but none was provided.

IV. INTEGRITY OF ARTICLES PUBLISHED ABOUT THE SANTILLI TELESCOPE

The article listed in item III.e.4. was published in the American Journal of Modern Physics by the Science Publishing Group. The journal and publisher are widely reported to be a scam that publishes articles without true peer-review as long as a fee is paid. I found that the Science Publishing Group is on Beall's List of Predatory Journals and Publishers. Beall's List is accepted by the scientific community as a resource that has thoroughly checked the integrity of a wide variety of scientific publications.

My conclusion after looking at specific articles from the Journal of American Modern Physics and other journals published by the Science Publishing Group is that this publisher and journal are careless, deceptive and fraudulent. There are many credibility problems with the journal. There is no editor-in-chief, but numerous editorial board members, many of whom are authors. Almost none of the board members or authors are located in the United States, despite the fact that the name of the journal is the "American Journal of Modern Physics." I recognize none of the scientists in this journal, and I found none to be employed at prestigious or highly respected institutions. Moreover, I looked at the Publisher's astronomy and planetary science journals and articles and recognize none of those authors, or co-authors, and I am very familiar with the U.S astronomy, astrophysics and planetary science community.

Another concern is that articles in the American Journal of Modern Physics are frequently received and accepted within a few days, even on major U.S. holidays (July 4, December 25). These short time periods tell me that the articles are not truly peer-reviewed, which usually takes at least a few weeks and often up to several months.

To get a feel for the journal, I pulled out a random special edition and a random article and found this article below, which turned out to be, incredibly enough, about Santilli's ideas, written by someone on his company's Board of Trustees:

Anderson, R. 2016 "Outline of Hadronic Mathematics, Mechanics and Chemistry as Conceived by R.M. Santilli," American Journal of Modern Physics, Volume 5, Issue 2-1, pages 1-16.

The author, Richard Anderson, is also listed as "lead guest editor" for the special edition of the journal, and the article gives his affiliation as on the Board of Trustees for the R.M. Santilli Foundation. I looked extensively online and see no listing of this Richard Anderson as a physicist, mathematician or chemist, and no record for him other than as a Board of Trustees member for the Santilli Foundation. Also, the Santilli Foundation website did not list any physics or educational credentials for Mr. Anderson. Editors for journals or special editions are selected for their broad knowledge of a field (or sub-field), which is needed to assemble a journal issue and monitor its quality. Based on what I found, Mr. Anderson is not qualified to be an editor for any reputable journal in physics and is unlikely to be an appropriately trained scientist.

I read through the Journal of American Modern Physics' archive region and found Santilli's name in the titles of several articles (as with the one above by R. Anderson), which I have never seen in the physics community. This is highly unusual and adds to the impropriety of the journal and articles.

I have more serious concerns about R. Anderson's aforementioned article. It was published two more times (at least) in the journal, approximately a year apart:

1. Anderson, R. 2015 "Outline of Hadronic Mathematics, Mechanics and Chemistry as Conceived by R.M. Santilli," American Journal of Modern Physics, Volume 4, Issue 5-1, pages 1-16.
2. Anderson, R. 2016 "Outline of Hadronic Mathematics, Mechanics and Chemistry as Conceived by R.M. Santilli," American Journal of Modern Physics, Volume 5, Issue 2-1, pages 1-16.
3. Anderson, R. 2017 "Outline of Hadronic Mathematics, Mechanics and Chemistry as Conceived by R.M. Santilli," American Journal of Modern Physics, Volume 6, Issue 4-1, pages 1-16.

The last two articles have the identical 'received' and 'accepted' dates: Aug 11, 2015 and Aug 24, 2015, which is impossible. This never happens in reputable journals, and is evidence of dishonest behavior on behalf of the publisher, journal and author, as it is unbelievable that this could have been an accidental mistake.

Regarding the journal article listed in III.e.5. 'Clifford Analysis,' I located the journal's website, which had one article by Santilli and another with his name in the title on the front page, but I could not get any farther without creating a login username and password. I did not find any credible electronic footprint of the journal on the Internet. It is not listed at the Astrophysical Data Systems Abstracts as a refereed journal, and so I conclude it is not providing peer-review.

V. THE SANTILLI TELESCOPE FUNCTION AND ANTIMATTER

As described in the video and articles listed above, the Santilli telescope is very similar in construction to a normal refracting telescope, which Santilli and his colleagues refer to as "Galileo telescopes." Refracting telescopes use convex lenses to collect and bend light down to a focus, which can be used to view and record an image of a distant object. The key difference with Santilli's telescope is that he replaces the convex lenses with concave, or diverging, lenses.

Instead of bringing light to a focus, concave lenses disperse light, and therefore, Santilli telescopes cannot produce focused images of astronomical objects.

Santilli apparently ordered two "Galileo" telescopes from "Galileo Telescopes" online seller and had one modified to his specifications (changing out convex for concave lenses). The store he listed does not carry this exact type of telescope anymore, but they do carry similar telescopes. Based on this site and my own experience, I estimate the cost to buy a new Galileo telescope to be in the range of $300 - $500, and another $200 - $300 to pay for the, presumably hand-modified, Santilli telescope.

Santilli acknowledges that his telescopes do not work for the typical stars and galaxies (that are made of ordinary matter) that most people are familiar with, but he says that they do work for stars and galaxies made of antimatter. He claims that this happens because antimatter emits light that is the "opposite" of light emitted from ordinary matter. In particular, he claims that light from antimatter has a negative index of refraction, and also that it is repelled by gravitational fields (rather than attracted as is the case for all light). He claims that these special properties are what allow the "antimatter light" to be focused through diverging concave lenses. These claims are not generally accepted in the scientific community and in fact are simply incorrect. Santilli provides no plausible evidence for this in his journal articles, nor citations of other work demonstrating any of this. His articles contain only preliminary ideas of how antimatter light might behave differently, with no extensive derivations, calculations or documentation of the proposed different optical behavior.

Antimatter exists, but it does not behave the way Santilli says it does, and would not be revealed using the Santilli Telescope. Antimatter can emit light, but this light is identical to light emitted from ordinary matter, as confirmed by experiment in 2017 with the CERN Antiproton decelerator (Ahmadi et al. 2017). Furthermore, index of refraction, 'n,' is a term used to describe the large-scale property of a material that light is passing through. A material can have slightly different values of 'n,' for different wavelengths of light (this effect is what gives rise to rainbows), but 'n' is not a property of light itself. It is even possible for a material to behave as if it has a negative index of refraction. This is discussed extensively in the scientific literature (see review by Smith et al. 2004), but not in any of the Santilli documentation that bring up negative index of refraction.

Santilli's claims that antimatter light is repelled by gravitational field of matter and has a negative index of refraction are incorrect, inappropriately documented, and therefore there is no scientific evidence to believe that his telescopes will work.

VI. OBSERVATIONS WITH THE SANTILLI TELESCOPE, ANALYSIS, PRESENTATION OF DATA AND ENTITIES

I have multiple concerns about how the observations were carried out. The reported techniques are not following standard observing protocol and the observers appear incompetent. A non-exhaustive list is given here:

1. Individual articles are not consistent about whether film- or electronic-cameras were used, or whether automatic ISO or 600 ISO was used.
2. In one instance they say that they used a Canon camera ISO 1600, but the accompanying figure captions say they used a Sony camera with automatic ISO.
3. There is no detailed table of observations.
4. Given the aperture size of the telescopes used, it is not believable that a galaxy would show up in 15 seconds.
5. The articles give an unconvincing argument for why not to use tracking; all observational astronomers use tracking to compensate for an object's apparent motion across the sky, which increases the signal-to-noise ratio.
6. They claim to focus their Santilli scopes by pairing them with a regular "Galileo" scope and focusing them both by the same amount; however, the pictures they present of lights on the bridge are clearly out of focus.
7. Pointing "horizontally over Tampa Bay" toward an astronomical source, but not listing astronomical coordinates.
8. The articles explain that the telescopes were ordered under the assurance by the manufacturer that they could see galaxies. No astronomers or physicists would accept this. They would calculate it themselves.
9. Santilli et al. did not even reduce their own data – credit goes to Mr. Scott Randall of Night Fox Productions. Scientists reduce and analyze their own data and explain the procedure in publication. If someone helped reduced it, they would go on the paper as a co-author and not be buried in the text.

10. There is no mention of standard data reduction procedure for images obtained with charge-couple devices (in digital cameras), such as taking and using dark frames, or correcting for flat-field response.

The images produced and claimed to be data from light and dark "entities" are also problematic. As explained in the video (III.e.2.), "entities" are what Santilli calls objects presumed to be composed of antimatter. The data, or images, claimed to have been produced by the Santilli telescope, of the entity candidates look like either like somebody moving in front of the camera with a lighted object, or out-of-focus dust particles on the optics (or detector), or possibly a diffraction pattern from a street light. In the same video (on page 4, line 16 of the transcript), they claim "our discoveries of invisible terrestrial entities has been independently verified by American astronomers on the internet." This is false. I found no evidence of this online after an extensive search, and they provide no evidence of such claims of verification or confirmation.

Santilli also claims that these entities move across the sky and he discusses their orbits. The orbits are not plausibly determined. There is no supporting evidence, such as description of the data or computer code needed for calculating the orbits. This is a nontrivial calculation that typically requires weeks or even months of recorded observations to compute the orbit of a new solar system object. Toward the end of the video, he devolves into speculation about surveillance of military with no supporting facts or documentation.

Conclusions

Based on the documents and videos I reviewed, there is no reason to believe that the Santilli telescope will work. Santilli claims to be presenting revolutionary technology and that the world is not ready to understand this. However, his articles and videos discuss ideas incorrectly referred to as 'physics' and published in a journal that is known to carry out fraudulent practices, including with articles published by a member of his Foundation's Board of Trustees. In my opinion, the American Journal of Modern Physics is correctly described as a fake journal that is not selective about whether the science in an article is accurate, so long as the author is willing to pay the publisher's fees. As described in published articles about Santilli telescopes, the astronomical observations were carried out in an incompetent manner and the images produced are not useful, nor convincing in the slightest. There is no evidence that they are using established

scientific methods. It is legitimate to question Santilli's methods, to conclude that his telescopes will not work, and to conclude that he is a "fringe scientist." Finally, it is also legitimate for a blog that reviews dubious scientific claims to question whether Santilli is a "mad professor" or "cunning scam artist," because all of the work presented for the Santilli Telescope is based on an incorrect foundation with incompetent observations. The telescope prices shown in the invoices are an order of magnitude higher than necessary for the materials involved. These telescopes cannot work as advertised, and it appears that Santilli is producing fraudulent articles and trying to pass them off as legitimate science in order to boost his sales.

Maria P. Womack, Ph.D. April 2, 2018

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Anderson, R. 2016 "Outline of Hadronic Mathematics, Mechanics and Chemistry as Conceived by R.M. Santilli," American Journal of Modern Physics, Volume 5, Issue 2-1, pages 1-16.

Anderson, R. 2017 "Outline of Hadronic Mathematics, Mechanics and Chemistry as Conceived by R.M. Santilli," American Journal of Modern Physics, Volume 6, Issue 4-1, pages 1-16.

Beall's list of predatory journals and publishers, website, 2018, available at https://beallslist.weebly.com

Clifford Analysis, Clifford Algebras and their Applications, website, 2018, available at http://nonlinearstudies.com/index.php/cacaa/login

Galileo Telescope online store, website, 2018, available at https://galileotelescope.com/contacts

R.M. Santilli Foundation website, 2018, available at http://www.santilli-galilei.com

Smith, D.R., Pendry, J.B., Wiltshire, 2004, "Metamaterials and Negative Refractive Index," Science, volume 305, issue 5685, pages 788-792.

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Education

Ph.D. Physics, Arizona State University, 1991
B.S. Physics, Florida State University, 1985

Observational astrophysicist with extensive history using telescopes at optical, infrared and millimeter/submillimeter wavelengths for research, and evaluating their roles in science policy. Skilled in scientific merit review, evaluation, creation and oversight of federally funded research programs in astronomy.

Professional Experience

Research Professor, Aug 2015 – present
Department of Physics, University of South Florida, Tampa, FL
Lead externally-funded research program in astrophysics; supervise graduate and undergraduate research students, contribute to STEM education efforts for under-represented groups, assist development of online courses and curriculum; establish and develop new science collaborations across the university and the state. Director of USF physics bridge-to-doctorate program.

Expert consultant, Feb 2016 – Jun 2016
Program Director, Jan 2011 - Jan 2015 (intergovernmental personnel assignment)
Division of Astronomical Sciences
National Science Foundation, Arlington, VA
Managed annual budget of $20 million; lead program director for the Stellar Astronomy and Astrophysics (Nov 2011-Jan 2014), and the Planetary Astronomy (Sep 2013 – Jan 2015) grant programs. I created and helped develop the new NSF-NASA partnership for observational extrasolar planet research: NN-EXPLORE; I reorganized the stellar astronomy and astrophysics and planetary astronomy programs, including establishing and assessing the NSF extrasolar planet portfolio. Other highlights include:

- Strategic planning and program development;
- Identified and supported emerging scientific trends and potentially transformative research and scholarship;
- Coordinated, scheduled and conducted review panels, identified and secured topical experts and made proposal assignments for merit review;
- Made funding recommendations based on merit review and budget allocations;
- Provided annual review, evaluation and oversight of funded programs;
- Conducted merit review and made well-justified funding recommendations for over 700 proposals; conveyed results to PIs;
- Worked with colleagues in Divisions of Physics (PHY), Materials Research (DMR)

and Chemistry (CHE) and Office of Multidisciplinary Activities (OMA) of the Math and Physical Sciences (MPS) Directorate and the Geosciences Directorate (GEO) to secure joint funding for meritorious proposals;
- Point-of-contact for NSF, and the inter-agency (NSF, NASA and DOE) coordinator for Congressionally-appointed Astronomy and Astrophysics Advisory Committee;
- Worked with colleagues to prepare and present information on NSF's extrasolar planet research initiatives to staffers of U.S. House of Representatives Science, Space and Technology Committee, Subcommittee on Research;
- Worked with colleagues to prepare follow-up testimony for NSF's extrasolar planet research initiatives, for the House Committee on Science, Space and Technology;
- Worked with colleagues to review and comment on draft testimony from the Department of the Air Force and the President's Science Advisor for a hearing on Threats from Space Objects, which was presented before the House Committee on Science, Space and Technology.

College Director of Assessment for Student Learning, 2008-2011
Director of the SCSU Observatory, 2004 – 2015
Interim Director for SCSU Planetarium, 2002
St Cloud State University, St. Cloud, MN
Worked with the Dean of the College of Science and Engineering, faculty and students to achieve research, teaching and assessment goals of the university; managed budgets and supervised student employees. Managed Observatory with two moderate-sized telescopes, spectrometer and imaging CCD, developed and conducted planetarium shows for classes and the public.

Professor of Physics and Astronomy, 2005 – Aug 2015
Associate Professor of Physics and Astronomy, 1999-2005, tenured 2000
Assistant Professor of Physics and Astronomy, 1997-1999
Department of Physics and Astronomy, St. Cloud State University, St. Cloud, Minnesota
Taught all levels of undergraduate physics and astronomy courses, including online format; conducted NSF- and NASA- funded research programs, including supervising 43 undergraduate researchers.

Research Scientist, 2007-2008
University of Central Florida, Department of Physics (sabbatical)
Initiated research program on extrasolar planet spectroscopy with Dr. J. Harrington.

Assistant Professor of Physics, 1994-1997
Pennsylvania State University at Erie, Division of Science
NASA-funded Planetary Science tenure-track faculty position: comet impact on Jupiter; conducted NSF-funded research programs with 8 undergraduate researchers.

Adjunct Associate Professor, 1994-1998
Visiting Professor, 1995-1996
Postdoctoral Research Associate, 1992-1994
Northern Arizona University, Department of Physics and Astronomy
Planetary science research, Native American astronomy outreach, research advising and mentoring for 7 undergraduate researchers, taught intro astronomy laboratory courses.

Postdoctoral Research Associate, 1991-1992
Arizona State University, Department of Chemistry.
Search for deuterated methane emission in interstellar molecular clouds.

Grant Support and Funding History

- 2016-2019: **PI, NSF Planetary Astronomy.** This grant supports observation, analysis and modeling of carbon monoxide emission in comets. Funding also supports supervision of graduate and undergraduate research projects at USF, including participation of women and underrepresented minorities, an industrial practicum for a doctoral student, and establishes new science collaborations across the university and the state.
- 2010-2015: **PI, NSF Planetary Astronomy**. This grant supported analysis and modeling of measured carbon monoxide emission in comets, including supervision of graduate and undergraduate research projects at SCSU.
- 2001-2005: **PI, NSF Planetary Astronomy**. Observational and analytical studies of simple organic molecules in comets. The observations were conducted at national and international mm/sub-mm facilities as well as at the optical observatory at the SCSU campus. Funding also supported new imaging and spectroscopic equipment purchases for the SCSU Observatory and student wages.
- 2001-2004: **PI, NASA Planetary Astronomy.** Reduce and analyze data for two comets.
- 1999-2001: **Co-I, Toyota Tapestry Grant**, supported equipment purchases and stipends for Minnesota high school teachers to learn how to use telescope equipment that their schools already owned; helped teachers learn research skills and make contributions to the American Association of Variable Star Observers.
- 1996-2002: **PI, NSF Faculty Early Career Development Program (CAREER)**. Grant funded comprehensive research program that was integrated with a strong educational component. The grant supported numerous observing trips for comet Hale-Bopp and many other bright comets at mm/sub-mm telescopes in Arizona and Hawaii. It also funded all equipment needed (including telescope, CCD camera and computers) to establish SCSU student-run observatory for optical imaging of comets, conducted simultaneously with the radio spectroscopy. It also funded dozens of undergraduate student researchers, including travel to observatories and conferences.
- 1997-1999: **PI, NASA Comet Hale-Bopp Program**. Funded mm-wave spectroscopy of comet Hale-Bopp, reducing and analyzing the data and publishing the results.
- 1998: **PI, Jorge Scientific Corporation Travel Grant**, funded travel to the International Astronomical Union conference at Tenerife Canary Islands so I could present research results on comet Hale-Bopp.
- 1994-1997: I was one of only a few **NASA Planetary Astronomy tenure-track faculty appointees** (the grant was awarded to Penn. State U. at Erie, R. Knacke, PI). This supported my academic year salary, so I could teach physics and astronomy courses and analyze infrared data of Jupiter related to the 1994 impact of comet Shoemaker-Levy 9.
- 1995-1996: **PI, NSF Astronomy**. While still a postdoctoral researcher at NAU, I initiated one of the first observational programs in the U.S. to apply the new technique of millimeter-wavelength spectroscopy in comets. This grant paid for subsequent analyses of these data, publications, and new observations.
- 1992-1996: **Co-I, NASA Origins of Solar Systems Program**. This award supported observation and analysis of molecular emissions from comets and interstellar clouds in order to constrain models of solar system formation.

- 1995-1996: **PI, American Astronomical Society Small Research and Travel grants** to pay for observational research on comet Hale-Bopp.

Telescope access granted at national and international facilities: $2M+ estimated value

- 2016 - 2018: Arizona Radio Observatory Submillimeter Telescope (ARO SMT) 10-m.
- 2016-2017: NASA Kepler 2 space observatory (K2).
- 2016: Institut de Radioastronomie Millimetrique (IRAM) 30-m telescope, Spain.
- 2016: Arizona Radio Observatory Kitt Peak 12-m telescope.
- 2011: W.M. Keck Observatory 10-m telescope, Hawaii.
- 1990-2005: National Radio Astronomy Observatory 12m telescope, Kitt Peak.
- 1990-1993: Caltech Submillimeter Observatory 10-m telescope, Hawaii.
- 1993-1995: National Undergraduate Research Observatory, Arizona.
- 1993-1994: James Clerk Maxwell Telescope, 15-m, Hawaii.
- 1988-1990: Kitt Peak National Observatory coude-feed.

Major Publications (chronological order)

1. Womack, M., Theobald, J. 1989, "Spatial Profiles of CN, C2, NH, NH2, H2O+, CO^+ and CO_2^+ in Comet P/ Halley," Publ. Astr. Soc. Pacific, 101, 881.
2. Womack, M., L.M. Ziurys, and S. Wyckoff, 1991, N_2H^+ in Orion: Chemical Clues to the Dynamics of the Quiescent Gas, Astrophysical Journal Letters, 370, L99.
3. Tegler, S.C., L.F. Burke, S. Wyckoff, M. Womack, U. Fink, M. DiSanti 1992, NH_3 and NH_2 in the Coma of Comet Brorsen-Metcalf, Astrophysical Journal, 384, 292.
4. Womack, M., L.M. Ziurys and S. Wyckoff, 1992, A Survey of N_2H^+ in Dense Clouds: Implications for Interstellar Ion-Molecule and Nitrogen Chemistry, Astrophysical Journal, 387, 417.
5. Womack, M., L.M. Ziurys and S. Wyckoff, 1992, Estimates of N_2 Abundances in Dense Molecular Clouds, Astrophysical Journal, 393, 188.
6. Womack, M., S. Wyckoff and L.M. Ziurys, 1992, Observational Constraints on Solar Nebula Nitrogen Chemistry: N_2/NH_3, Astrophysical Journal, 401, 728.
7. Lutz, B.L., M. Womack, and R.M. Wagner, 1993, Ion Abundances and Implications for Photochemistry in Comets Halley (1986 III) and Bradfield (1987 XXIX), Astrophysical Journal, 407, 402.
8. Womack, M., L.M. Ziurys, and L. Sage, 1993, N_2H^+ in the Orion Ambient Ridge: Cloud Clumping vs. Rotation, Astrophysical Journal Letters, 406, L29.
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14. Womack, M., Festou, M.C., Stern, S.A. and Homich, A. 1997, Maps of HCO^+ Emission in C/1995 O1 (Hale-Bopp), Earth, Moon and Planets (Hale-Bopp Edition),

vol. 77, no. 3, 259-264.
15. Braunstein, M., Womack, M., et al. 1997, A CCD Image Archive of Comet C/1995 O1 (Hale-Bopp): Dust Expansion Velocities, Earth, Moon and Planets (Hale-Bopp Edition), vol. 78, no. 1, 219-227.
16. Womack, M. and Stern, S.A. 1999, The Detection of CO in 2060 Chiron, Solar System Res., vol. 33, p. 187.
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25. Womack, M., Sarid, G., Wierzchos, K. 2017, "Carbon monoxide and other volatiles in distant comets," Publications of the Astronomical Society of the Pacific, topical review article, 129, 973.
26. Wierzchos, K., Womack, M., Sarid, G., 2017, "Carbon monoxide in the distantly active Centaur (60558) 174P/Echeclus at 6 au," Astronomical Journal, 153, 5, 230.
27. Womack, M., Curtis, A., Lastra, N., Harrington Pinto, O., Rabson, D.A., Wierzchos, K., Cox, T., Rivera, I., Mentzer, C., Ruffini, N., Jackson, C., and Micciche, A., 2018, "Comet C/1995 O1(Hale-Bopp) Visual Lightcurve V1.0," NASA Planetary Data System, submitted.
28. Wierzchos, K., Womack, M. 2018, "C/2016 R2 (Pan-STARRS): A comet enriched with the hypervolatiles CO and N2," Astronomical Journal, submitted.

International Astronomical Union Telegrams

1. Womack, M., S.A. Stern, 1994, "Upper Limits to CO in 2060 Chiron," IAUC 5957.
2. Womack, M., Stern, S.A., Festou, M.C. 1995, "CO in Hale-Bopp," IAUC 6276.
3. Womack, M., Stern, S.A. 1995, "Detection of CO in 2060 Chiron," IAUC 6193.
4. Womack, M., Festou, M.C., and Stern, S.A. 1996, "CO, HCN, CH_3OH and H_2CO in Comet Hyakutake (1996 B2)," IAUC 6345.
5. Womack, M., Woodney, L.M., Festou, M.C., McMullin, J., A'Hearn, M., Suswal, D., and Stern, S.A. 1996, "Detection of Methanol in Hale-Bopp," IAUC 6382.
6. Woodney, L., Womack, M., et al. 1996, "Detection of H_2S in Hale-Bopp," IAUC 6408.
7. Womack, M., and Suswal, D. 1996, "Detection of HCN in Comet Tabur," IAUC 6485.
8. Womack, M., Faith, D., Festou, M.C., Slater, D., and Stern, S.A. 1997, "Ortho-to-para Ratio in Hale-Bopp," IAUC 6542.
9. Wierzchos, K., and Womack, M., 2017, "Detection of CO in comet C/2016 R2," Central Bureau for Electronic Telegram No. 4464.

Other relevant professional publications

1. Womack, M. 2015, "Astronomy Decadal Reports Primer," Astrobetter, http://www.astrobetter.com/blog/2015/09/09/astronomy-decadal-reports-primer-new-worlds-new-horizons-visions-voyages-and-nsf-portfolio-review-committee/
2. Womack, M. 2015, "The Astronomy OIR Study recommendations for the LSST era," Astrobetter, http://www.astrobetter.com/blog/2015/09/16/the-astronomy-oir-study-recommendations-for-the-lsst-era/
3. Womack, M. 2015, "How will NSF pay for the Astronomy OIR Study recommendations?" Astrobetter, http://www.astrobetter.com/blog/2015/09/22/how-to-pay-for-the-oir-study-recommendations/

News Releases and Other Contact with Media

"Bizarro Comet Challenging Central Florida Researchers," 2017, UCF press release.
"Gravitational waves discovered: top scientists respond," 2016, in The Conversation, expert panel opinion piece, reprinted in Newsweek and US News & World Report.
"Hitching a Ride on Comet 29P," 2016, USF News.
"Rosetta captures comet dust after finally finding Philae," 2016, in Chemistry World, contributed expert comments to article about press release for European spacecraft mission.
"Comet 67P's carbon blanket promises solar system birth insights," 2015, in Chemistry World, contributed expert comments to article about European spacecraft result.
"Contemplating the Chemical Composition of Comets and Exoplanets," 2015, People Behind the Science podcast with Marie McNeely.
"Global perspectives on a comet," 2014, NSF Press release about comet ISON photography contest, reprinted in Astrobiology Magazine, CBSNews.
"Celestial Pollution," 2013, Gemini Observatory Press Release about meteor shower, reprinted in Space.com.
"Spiral arms hint at the presence of planets," 2011 in NSF Press Release.
"An Inside Look at NSF," Fundamentals Newsletter, SCSU, 2012
"NASA Mission Hits Home," University Chronicle, 2005
"SCSU Professor, Students Train Eyes on NASA Mission," WCCO, 2005
"SCSU's Womack monitored Deep Impact from home," St. Cloud Times, 2005
"Astronomers' Holiday Special – a July 4 Comet Bash", University of Arizona News, 2005

"Students of SCSU Professor's space camp get patch launched," St. Cloud Times, 1998
"Cometwatcher," Research Penn State, 1997
Multiple other radio, television and social media interviews for unusual events (e.g. comets, solar and lunar eclipses, meteors, brooms "standing on end") since 1991

Meeting Abstracts and Presentations (chronological order)

1. Wyckoff, S.; Wehinger, P. A.; Belton, M. J. S.; Spinrad; Wagner, R. M.; Womack, M., 1986, "Spectral Evolution of Comet P/Halley: 1984-1986", BAAS, 18, 813.
2. Wyckoff, S., P.A. Wehinger, M. Womack, A.J. Ferro, B.A. Peterson, S. Tegler, and J. Theobald 1987, ``Optical Spectroscopy of Comet Halley", B.A.A.S., 19, No. 3.
3. Womack, M. and Theobald, J. 1988, ``Violet and Red Systems of CN in the Spectrum of Comet Halley", B.A.A.S., 20, No. 3.
4. Womack, M. and Theobald, J. 1989 ``Spatial Profiles of Free Radicals in Comet Halley", Astron. Soc. Pacific, Berkeley Meeting, June 1989.
5. Womack, M. and S. Wyckoff, 1989, ``Spatial Distributions of Molecules in Comet Halley", B.A.A.S., 21, No. 3.
6. Wehinger, P.A., Wyckoff, S., Womack, M., Peterson, B.A., 1989, "Echelle Spectra of the CN (0,0) Violet system in comet Brorsen-Metcalf", BAAS, 21, 933.
7. Womack, M., P. Wehinger, S. Wyckoff, and B. Peterson, 1990, ``The 12CN/13CN Abundance Ratio in Comets and Local Interstellar Medium", BAAS, 21, 4, 1124.
8. Womack, M., P.A. Wehinger, S. Wyckoff, and B.A. Peterson, 1990, ``The 12CN/13CN Abundance Ratio in the Local Interstellar Medium", Protostars and Planets III meeting.
9. Womack, M., L.M. Ziurys, and S. Wyckoff, 1990, `` N2H+ in Warm and Cold Clouds", B.A.A.S., 22, No. 2, 800
10. Burke, L.F., S.C. Tegler, S. Wyckoff, M. Womack, U. Fink, and M. DiSanti, 1990, ``NH2 in the Coma of Comet Brorsen-Metcalf", B.A.A.S, 22, No. 3.
11. Wyckoff, S., S.C. Tegler, L. Engel, M. Womack, A. Ferro and B. Peterson, 1990, ``Ammonia and N Abundances in Comets", B.A.A.S., 22, No. 3.
12. Womack, M., S. Wyckoff, P.A. Wehinger, and B.A. Peterson, 1990, ``A Spectroscopic Atlas of Comet Halley (3200 – 9200A)", B.A.A.S., 22, No. 3.
13. Womack, M., Ziurys, L.M., Wyckoff, S., and Sage, L. 1991, ``N2H+ in Orion: Two Clouds at KL/IRc2?", B.A.A.S., 22, No. 4, 1329.
14. Womack, M. 1991, `` N2H+ in the Orion Quiescent Gas", Steward Obs. Internal Symposium.
15. Womack, M., S. Wyckoff, and L.M. Ziurys, 1991, ``Molecular Cloud Diagnostics of Solar Nebula Chemistry", B.A.A.S., 23, No. 3, 1232.
16. Wyckoff, S., M. Womack and L.M. Ziurys, 1991, ``Cometary Diagnostics of Solar Nebula Chemistry", B.A.A.S., 23, No. 3, 1234.
17. Womack, M., Lutz, B.L., and R.M. Wagner, 1992, ``Molecular Ions in Comets Halley and Bradfield (1987 XXIX)", B.A.A.S., 24, No. 3, 999.
18. Womack, M., L.M. Ziurys and L.J. Sage, 1993, ``Cloud Clumping of the Orion Ambient Ridge: No Rotation About KL/IRc2", B.A.A.S., 24, No. 4, 1199.
19. Womack, M., and S. McKeown, 1993, ``Millimeter-Wavelength Spectra of H2CO and CH3OH in Comet Swift-Tuttle", B.A.A.S. 25, No. 3, 1050.
20. Lutz, B.L., and M. Womack, 1993, ``Pre- and Post-Perihelion Spectroscopy of Comet Halley", B.A.A.S. 25, No. 3, 1050.
21. Womack, M., and Stern, S.A. 1994, ``Search for CO and HCN in Chiron", BAAS, 26,

No. 3.
22. Womack, M., Ziurys, L.M., Apponi, A.J. and Yoder, J.T. 1994, “Interstellar CH3D: Deuterated methane in the Orion hot core?,” AIP 312, 305.
23. Graham, R.A., and Womack, M. 1995 ``Carbon monoxide in the Coma of P/Schwassmann-Wachmann 1", B.A.A.S., 186, 33.01.
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25. Womack, M. ``Carbon Chemistry in Comets", Topics in Modern Astronomy, American Assoc. of Physics Teachers, Aug. 1995.
26. Womack, M., Stern, S.A. 1995, `` Detection of CO in Chiron", BAAS, 27, 33.07.
27. Womack, M., Festou, M.C., and Stern, S.A. 1996, `` CO, HCN, CH3OH and H2CO in Comet Hyakutake Before, During and After Perihelion", B.A.A.S., 28, 188.
28. Womack, M. Panel Discussion on Comet Hyakutake, at American Astronomical Society meeting, June 1996.
29. Womack, M., Festou, M., and Stern, S.A. 1996, ``Parent Molecules in Comet Hyakutake", ACM meeting, July 1996.
30. Womack, M., Suswal, D., Festou, M., Stern, S.A., and Slater, D. 1996, ``Millimeter-wavelength Spectroscopy of Comets Hyakutake and Hale-Bopp", B.A.A.S., 29.
31. Womack, M., Festou, M.C., Mangum, J., and Stern, S.A., 1997, ``Millimeter-wavelength Images of Gaseous Emission in C/1995 O1 (Hale-Bopp)", BAAS 29, 3406.
32. Pinnick, D.A., Womack, M., Moore, G., Faith, D., Wiest, A., Modi, C., Ricotta, J., and Suswal, D. 1997, ``Optical Images of C/1995 O1 (Hale-Bopp) During Perihelion", BAAS, 29, 3214.
33. Spinar, M., Womack, M., and Goldschen, M. 1998, ``HCN and CO Emission in Comet C/1996 Q1 (Tabur)," B.A.A.S. 30, 4010
34. Festou, M.C., Barale, O., Davidge, T., Stern, S.A., Tozzi, G.P., Womack, M., and Zucconi, J.M. 1998, ``Tentative Identification of the Parent of CN radicals in Comets: = C_2N_2", B.A.A.S. 30, 4002.
35. Womack, M., Festou, M.C., and Stern, S.A. 1998, ``The Heliocentric Evolution of Carbon-Bearing Volatiles in Comet Hale-Bopp", B.A.A.S., 30, 3111.
36. Homich, A. Womack, M., and Uhl, W.T. 1998, ``Correlations between CO and HCN Production Rates and Absolute Visual Magnitudes in Comet Hale-Bopp", B.A.A.S., 30, 3108.
37. Deglman, F.; Womack, M.; Braunstein, M.; Pinnick, D.A.; Aaker, G.; Goldschen, M.; Zilka, J.; Henning, B.; Comstock, R.; Hoffman, P.; Faith, D.; Moore, S.; Ricotta, J.; Wiest, A.; and Modi, C. 1998, ``An Optical Archive of Comet Hale-Bopp: Dust Expansion Velocities and the Evolution of Coma Morphology", B.A.A.S., 300, 2910.
38. Womack, M., Festou, M.C., Stern, S.A., and J. Mangum, 1998, ``Mm-wave maps of HCO+ Emission and Molecular Ion Morphologies in C/1995 O1 (Hale-Bopp)", First International Meeting of Comet Hale-Bopp, Tenerife, Proceedings, 53.
39. Braunstein, M., Womack, M., Deglman, F., Pinnick, D., Faith, D., Modi, C., Moore, S., Ricotta, J., Wiest, A., Ben-Bassat, O., Ruiz, J. 1998, ``CCD Image Archive of Comet C/1995 (O1) Hale-Bopp", First International Meeting of Comet Hale-Bopp, Tenerife, 69.
40. Womack, M. "On the Activity of Distant Comets", Invited speaker, Asteroids, Comets and Meteors Meeting, 1999, Ithaca, NY.

41. Womack, M. and Homich, A. "Comparison of Long-term Activity of Comet Hale-Bopp at Visible and Mm-wavelengths", 1998, B.A.A.S., 31, 1709.
42. Womack, M., Pinnick, D.A., Mangum, J.G., Festou, M.C., Stern, S.A. 1999, "On the Fly Imaging of Neutral and Ionized Molecules in Comet Hale-Bopp", Conference at Radio through Submillimeter Wavelengths, Tucson, AZ
43. Pinnick, D.A. and Womack, M. 1999, "Spectral Analyses of HCN and CO Emission Maps of Comet Hale-Bopp," BAAS, 31, 1589.
44. Womack, M 2000, "Cometary Activity Beyond 4 AU", BAAS, 32, 4124.
45. Womack, M. 2000, "COMETWATCHERS: Bringing Research into the Undergraduate Astronomy Curriculum," BAAS, 32, 875.
46. Crovisier, J., Biver, N., Moreno, R., Lis, D., Bockelee-Morvan, D., Womack, M., Colom, P., Henry, F., Lecacheux, A., Paubert, G., Despois, D., and Weaver, H.A. 2001, "Spectroscopic Investigation of Comets C/1999 T1 (McNaught-Hartley) and C/2001 A2 (Linear) at Radio Wavelengths: Evidence for Chemical Diversity", BAAS, 33, 4306.
47. Cabanela, J., Womack, M., & Dickey, J.M. 2001, "Deep CO Observations of Four LSBs", BAAS, 199, 710.
48. Womack, M., Festou, M., Pinnick, D., Mangum, J.G. 2002, "OTF images and asymmetric outgassing from comet Hale-Bopp", BAAS, 34, 1607.
49. Festou, M., Womack, M., Pinnick, D., Mangum, J., 2002, "How anisotropic was the gas coma of comet C/Hale-Bopp?", BAAS, 34, 1212.
50. Milam, S., Womack, M., Ziurys, L.M., Wyckoff, S. 2005, "Simple Organics in Comets: Formaldehyde, Methyl Cyanide and Methanol", IAU Symposium, Asilomar.
51. Womack, M., S. Choi, M. Gesmundo, J. Swanson, 2007, "CO, HCN and H2S in comet C/2001 Q4 (NEAT), BAAS, 39, 5308.
52. Womack, M., Harrington, J., Deming, D., Rojo, P., Fortney, J.J. 2008, "The search for water in HD209458b with transit spectroscopy over 0.7–2.4 micron", BAAS, 40, 1109
53. Womack, M., Harrington, J., Rojo, P., Deming, D, Fortney, J. 2010, "A ground-based search for water in HD 209458b using transit spectroscopy," proceedings UCF Winter Workshop: Exoplanets for Planetary Scientists, http://planets.ucf.edu/node/206.
54. Womack, M., Sarid, G., Wierzchos, K. 2016, "Gaseous activity of distant comets," Bulletin of the American Astronomical Society, 483, 3006.
55. Wierzchos, K. and Womack, M. 2016, "CO in Centaur Echelus," Bulletin of the American Astronomical Society, 481,604.
56. Wierzchos, K., Womack, M., "Detection of CO and HCN in the coma of Jupiter-family comet 41P/Tuttle-Giacobini-Kresak," BAAS, 493, 508.
57. Dones, H.C.L., Womack, M., Alvarellos, Jose, Bierhaus, E., Bottke, W., Hamill, P., Nesvorny, D., Robbins, S., Zahnle, K. 2017, BAAS 483, 102.
58. Womack, M. Lastra, N., Harrington, O., Cutis, A., Wierzchos, K., Ruffini, N., Mentzer, C., Rabson, D., Cox, T., Rivera, I., Micciche, A. "New Methods for deriving cometary secular lightcurves: C/1995 O1 (Hale-Bopp) revisited," BAAS, 494, 2001.
59. Harrington, O., Womack, M., Lastra, N., Curtis, A., 2017, "Correlation between cometary gas/dust ratios and heliocentric distance," BAAS, 494, 1417.
60. Dones, H.C.L., Womack, M., Nesvorny, D., Bierhaus, E., Zahnle, K., Robbins, S., Bottke, W., lvrellos, J., Hamill, P. 2017, "Can Ecliptic comets be created en route from the Kuiper Belt," BAAS, 494, 102.

Meeting Proceedings

1. Womack, M., 1990, `` N2H+ in Warm and Cold Clouds", Workshop on Observations of Recent Comets (1990), ed. W.F. Huebner, P.A. Wehinger, J. Rahe, I. Konno, Southwest Research Institute, 110.
2. Womack, M. , Ziurys, L.M., Apponi, A.J., and Yoder, J.T. 1994, ``Interstellar CH3D: Deuterated Methane in the Orion Hot Core?", Physical Chemistry of Molecules and Grains in Space meeting, Mont Sainte-Odile (France), 305.
3. Womack, M., and Stern, S.A., 1997, ``Observations of Carbon Monoxide in (2060) Chiron", LPSC, 28, 1575.
4. Stern, S.A, Womack, M., and Festou, M.C. 1997, ``Heliocentric Evolution of Key Species in Comet C/1995 O1 (Hale-Bopp)", LPSC, 28, 1375.
5. Womack, M. 2010, "Challenges of a Ground-based Search for Water in a Hot Jupiter: HD 209458b," review, proceedings Univ. Central Florida Winter Workshop: Exoplanets for Planetary Scientists, http://planets.ucf.edu/node/206.

Society Membership

American Astronomical Society (AAS)
Division for Planetary Sciences
International Astronomical Union
Division F Commission 15 Physical Study of Comets & Minor Planets
Division F Commission 51 Bio-Astronomy
Division F Commission 53 Extrasolar Planets

Teaching and Assessment Experience

While at St. Cloud State, I taught all levels of physics and astronomy courses, including online format. I oversaw all aspects of the astrophysics track of the B.S. physics major, and the B.S. Physics Education major. This included program development and assessment, modernization and reform, course curriculum development, undergraduate-student advising, and mentoring. I also led efforts to enhance undergraduate student facilities (including the observatory and physics major computing lab). Other highlights include:

- Helped develop the Physics Education curriculum to meet the State of Minnesota Board of Teacher Education new licensure requirements for junior and senior high school teacher candidates;
- Led the department through the university-wide general education overhaul, including coordination with statewide transfer curriculum standards;
- Secured final approval of our general education courses and oversight of the early stages of implementation;
- Worked with colleagues to write and publish physics and astronomy laboratory exercise manuals, which raised over $100,000 for departmental laboratory equipment, supplies and student scholarships for recruitment.

During 2009-2011 I served as an **elected member of the Minnesota Online Academic Services Committee**. Review, develop, and recommend to the Minnesota Online Council guidelines, policies, and/or procedures that will promote strategic curriculum development and technology employment that applies best practices regarding online learning into the design and delivery of courses within the Minnesota State Colleges and Universities system.

I served as the **Director of Student Learning Assessment** for the College of Sciences and

Engineering at SCSU for three years. I led monthly meetings with faculty representatives to set goals, document assessment of goals, and kept departments on track for monthly and annual deadlines for accreditation. Other major responsibilities were to:

- Prepare and present annual reports to the Dean of the College summarizing and analyzing all the departments' progress toward meeting the Higher Learning Commission (HLC) goals, identifying successes and concerns in academic programs;
- Lead the College through completion of accreditation process with the HLC;
- Help the College meet annual goals and satisfy requirements for the university in 2010 for the HLC's Academy for Assessment, needed for HLC accreditation.

Significant Educational and Public Outreach

During summers from 1994 – 1998 I was the **Lead instructor and facilitator for "Stargazer" Workshop** at Northern Arizona University. I worked with Navajo astronomers Nancy Maryboy and David Begay and NAU professor Barry Lutz to develop a joint Western-Navajo astronomy curriculum for "Stargazer." This camp was selected for special recognition by NASA and given the opportunity to fly a piece of student-produced artwork from the Stargazer camp aboard NASA Space Shuttle STS-88 Endeavour flight. I also conducted other astronomical public observing sessions on the Navajo reservations.

During summers 1995 and 1996 I was **Instructor for the NAU/NASA Jupiter Watch** undergraduate research program, which recruited students nationally for research training with the 30-inch National Undergraduate Research Observatory (optical) telescope. I taught students data collection, reduction and analysis techniques using National Optical Astronomy Observatory (NOAO)'s IRAF software.

From 1997 – 2011 I developed and gave dozens of planetarium shows to university students and members of the public, including many public-astronomy nights. In 2002 I was the interim **SCSU Planetarium Director**, during which time I oversaw the operation of the planetarium, including the budget, trained and supervised student employees.

From 2004 - 2015 I was **Director of the SCSU Observatory,** for which I manage the budget, scheduling, operation and maintenance of the on-campus student-run observatory. I also:

- Secured funding from NSF for a $60,000 upgrade to the observatory with two telescopes, imaging and spectroscopic CCD cameras, filters, and computers;
- Trained students to conduct research with the observatory, and to assist with public observing nights;
- Supervised over 30 paid student research assistants to conduct observations and analyze results using advanced computer techniques

Invited Talks, Presentations and Workshops

2018	NASA SSERVI Workshop, "Carbon in Comets"
2017	NSF CAREER Workshop, USF, keynote speaker
2015	NSF Grant Strategies Workshop, USF
2015	University of Central Florida, Dept of Physics, "Carbon monoxide in Comets," colloquium
2015	University of South Florida, Dept of Physics, "Writing a great research proposal" graduate seminar lecture for USF Bridge program
2014	University of South Florida, Dept of Physics, "Research communities and the

craft of proposal writing," graduate seminar lecture
2013 University of S. Florida, Dept. of Physics, "Proposal writing: Selling your Best Idea," graduate seminar lecture
2011 St. Cloud State University, "NSF Funding Opportunities and Tips for Success;"
2010 Minnesota State University Moorhead, Department of Physics and Astronomy, "Using Spectra to Probe Cometary Atmospheres," colloquium
2010 Winter Workshop at University of Central Florida: Exoplanets for Planetary Scientists, "Challenges of a Ground-based Search for Water in a Hot Jupiter: HD 209458b," invited review talk
2009 University of South Florida, Department of Physics, "Spectral Clues to the Origin of Organic Molecules in Comets," colloquium
2009 SCSU, "A Guided Tour of Five Exotic Exoplanets," public lecture
2000 Univ. of Toledo Dept. of Physics and Astronomy, "Outbursts in Comets at Large Heliocentric Distances," colloquium
1999 American Astronomical Society meeting (Atlanta), invited session for NSF CAREER Awardees, "Cometary Activity Beyond 4 AU"
1999 NRAO Conference: Imaging at Radio through Submillimeter Wavelengths, "On the Fly Imaging of Comet Hale-Bopp," invited review
1999 University of Minnesota Astronomy Dept, "Millimeter-wavelength Observations of Comet Hale-Bopp," colloquium
1999 Asteroids, Comets, and Meteors meeting, Cornell University, "On the Activity of Distant Comets," invited review
1999 Minnesota Optical Society, "Millimeter-wavelength Spectral Imaging of Comets: New Insights into Gas Dynamics"
1998 Western Regional NASA Space Grant meeting, "Native American Astronomy Education in the Stargazer Program," invited speaker
1996 Panel Discussion on Comet Hyakutake, American Astronomical Society meeting, Madison, WI
1995 American Association for Physics Teachers meeting, Spokane, WA, "Carbon Chemistry in Comets," invited review
1996 Univ. of Toledo Dept. of Physics and Astronomy, "Observational Constraints to Solar System Formation," colloquium
1995 Pennsylvania State Univ. at Erie, Division of Science, "Millimeter-wavelength Observations of Organic Species in Comets," colloquium
1996 Max Planck Institut fur Astronomie, Bonn, "$N2H^+$ in Quiescent Gas: Evidence for Colliding Clouds," colloquium
1991 Univ. Massachusetts at Amherst, "Interstellar Nitrogen Chemistry as Revealed from Observations of $N2H^+$," colloquium

Additional Professional and Public Service

SCSU Faculty Senate, 2008-2010
SCSU University Steering Committee on Assessment of Student Learning, 2008-2011
SCSU College of Science and Engineering Curriculum Committee, 2005-2007
SCSU College of Science and Engineering Assessment Committee, 2000-2011
SCSU Committee on the Institution, 2006-2011
SCSU Master's thesis committee member, M.S. Electrical Engineering, S.Y. Choi, "Automatic modulation classification on software defined radio," 2008-2009
SCSU Chair, search committee for department faculty positions, multiple years

SCSU Public Observing Nights, 1997-2010
SCSU Planetarium Shows, 1997-2010
Workshops with High School Teachers on observing variable stars, 1999-2000, Minnesota
SCSU Faculty advisor to students majoring in physics, radiologic technology and nuclear medical technology, 1994-2011
SCSU Committee of student workers, 1997-2011
SCSU Departmental committee of retention, promotion and tenure, 2005-2011
SCSU Working group, Wiki-users, 2008-2010
Faculty advisor, Penn State Erie, Women in Science and Engineering, 1994-1997
NSF Review Panels and external reviewer, since 1993
NASA Review Panels and external reviewer, since 1992
Reviewer for journals Icarus and Astrophysical Journal, since 1994
Scientific Organizing Comm., for International Astronomical Union Colloquium No.186: "Cometary Science after Hale-Bopp" meeting in Tenerife, Canary Islands, 2000-2002
NASA Planetary Data Systems Small Bodies Node International Halley Watch Peer Review Committee, 1993
Public lectures on astronomical topics, since 1995
Coach, "Odyssey of the Mind" problem-solving tournament, 2012
Astronomy Day activities with tourists on the National Mall, Washington, DC, 2013
Public and professional outreach with social media, since 2013
Advice and mentoring to Aspiration Creation group working with European Space Agency to involve African American students with Mars research, 2015.
http://www.planetary.org/blogs/guest-blogs/2016/0226-atlanta students-bring-mars-to-earth.html

Student Research Supervised

Students are listed according to year the work started. Also listed are the students' occupations after graduation, when known. Funds for the SCSU Observatory equipment and student wages were obtained from National Science Foundation grants. Research requirements were frequently incorporated in all upper level undergraduate astrophysics courses at SCSU; undergraduate research at USF conducted to fulfill requirements for the physics major.

1993

1. Sean McKeown, "Mm-wave Spectroscopy of Comet Swift-Tuttle" (REU student at NAU), B.S. 1994 Physics and Theology, Georgetown Univ., M.S. Physics, Northwestern University. Now I.T. Director at Oracle Corp.

2. Bret Huggard, "Optical Imaging of Collision of Comet SL9 with Jupiter," and "HST Ultraviolet spectroscopy of Interstellar Clouds." B.S. 1996, Physics and Astronomy, Northern Arizona Univ., later telescope operator and electronics technician at Kitt Peak National Observatory, Arizona.

3. Kartik Sheth, "Interstellar Optical Spectroscopy," (REU student at NAU), B.S. Grinnell College, Ph.D. Astronomy Univ. Maryland, co-supervised with B. Lutz. Now Deputy Program Scientist at NASA.

1994

4. Brian Cudnik, "Optical Imaging of Jupiter and Mars." B.S. 1994, Physics and Astronomy, NAU, M.S. San Diego State University, 1998. Now Laboratory Specialist at Prairie View A&M University

5. Ray Graham, "CO spectra of Comet P/Schwassmann-Wachmann 1," B.S. 1997, Electrical Engineering, Penn State Erie, Engineer at Harris Corporation, Aerospace Division. Now President of Bitwise Design.

1995

6. Dennis Faith, "Imaging Comet Hale-Bopp," B.S. Biology 1997, Penn State Erie. Now physician at FirstLight Health System, Minnesota.

1996

7. Oren Ben-Bassat, "CCD Imaging of Comet Hale-Bopp," B.S. Physics, 1997, Brandeis Univ., Ph.D. Mathematics, University of Pennsylvania 2006. Later at Einstein Institute of Mathematics.

8. Javier Ruiz, "CCD Imaging of Comet Hale-Bopp", B.S. Physics, 1997, NAU.

9. Dave Suswal, "Mm-wave spectroscopy of Comet Hale-Bopp," B.S. Physics, 1997, Penn State Erie, Special Education aide, Deary High School, Deary, Idaho.

10. Steve Spencer, "Infrared Spectroscopy of Jupiter," B.S. Math, 1997, Penn State Erie, systems engineer, Aquilent.

1997

11. Chintan Modi, "CCD Imaging of Comet Hale-Bopp," B.S. Biochemistry and Molecular Biology, Penn State University. Now working at Merck Co.

12. Jack Ricotta, "CCD Imaging of Comet Hale-Bopp," B.S. Mech. Engineering, Penn State Univ., lead application developer at Progressive Insurance.

13. Scott Moore, "CCD Imaging of Comet Hale-Bopp," Environmental Science major at Penn State University, Now posting Specialist and Internet Research Assistant at Penn State Univ.

14. Aric Wiest, "Photography and CCD Imaging of Comet Hale-Bopp," B.S. Biology, 1998, Penn State Erie, M.S., Biology at Texas A&M University, 2002. Now faculty member at Univ. Missouri-Kansas City.

15. Trevor Uhl, "Mm-wave Spectroscopy of Comet Hale-Bopp," (REU student at NAU), B.S. Physics and Astronomy 1997, Yale University, Now at Investment Research & Risk Analysis at Reliance Funds, NY.

16. Jean Zilka, "Data Reducation and Analysis of Comet Hale-Bopp," B.E.S. Physics, 1999, SCSU. Now working at DeVry Univ.

17. Frank Deglman, "CCD Imaging and Data Reduction of Comets with SCSU Observatory," B.S. Physics, 1996, SCSU. Now telescope operator and engineer at McDonald Observatory.

18. April Homich, "CCD Imaging and Analysis of Comets" and "Mm-wave Spectroscopy of Comets," B.S. Physics, SCSU, 2000, M.S. Astronomy University of Minnesota, 2003.

1998

19. Marcel Goldschen-Ohm, "Analysis of Dust Jets in Comet Hale-Bopp", "Stellar spectroscopy", in ASTR 312, B.S. physics, SCSU. Ph.D., Physics, 2009, Univ. Wisconsin-Madison, assistant scientist at UW-Madison.

20. Ahnie Jacobson, "Image Reduction of Comet Hale-Bopp", B.A. Math, 1998, College of St. Benedict, M.S. Applied and Computational Mathematics, U. of Minnesota, Duluth.

21. Mike Spinar, "Mm-wave Imaging of Comet Hale-Bopp," B.S. Meteorology, 2001, SCSU. Now graduate student in atmospheric science, University of Illinois, Urbana-Champaign

22. Brian Henning, "CCD Imaging of Comets," B.A. computer science, SCSU, 2001, senior engineer at Target.

23. Grant Aaker, "Analysis of Dust Jets in Comet Hale-Bopp," post-secondary student, B.S. Lewis and Clark College, philosophy. Currently in med school at Cornell and filmmaker.

24. Aaron Lemke, "Image Reduction of Comet Hale-Bopp Data," post-secondary student.

25. Sarah Reed, "CCD Imaging of Comets with SCSU Observatory," also in ASTR 311, B.S. Physics 2002; UC at Berkeley, Environmental Science, Policy and Management, Ph.D. 2013, postdoctoral scholar at Lawrence Hall of Science at UC-Berkeley.

1999

26. Andrea Tollison, "CCD Imaging of Comets with SCSU Observatory," in ASTR 311, B.S. Physics, SCSU. Edmund Industrial Optics, Data Systems Analyst at Mastery Charter Schools.

27. Jessica Hafner, "CCD Imaging of Comets with SCSU Observatory," undeclared, SCSU

28. Jason Cook, "CCD Imaging of Comets with SCSU Observatory," in ASTR 311, B.S. physical science education major, SCSU. Now teaching high school.

29. Steven Dorsher, "CCD Imaging of Comets with SCSU Observatory," in ASTR 311, post-secondary student, SCSU, member US TEAM 2000 Physics Olympiad. Now graduate student in physics at Louisiana State University.

2000

30. Laura Lockwood, "Stellar Spectroscopy with SCSU Observatory," in ASTR 312, B.S. Meteorology, SCSU, 2002, now meteorologist, Director of Operations, Weatherology.

31. Corey Strom, "Variable Star Lightcurves" in ASTR 312, ASTR 323 CCD Imaging of Comets, B.S. Physics, SCSU, B&C Plumbing.

32. Andy Matt, "Stellar Spectroscopy with SCSU Observatory" in ASTR 312, computer science, SCSU

33. Kar-Yeong Teoh, "Scientific Databases on the Internet, computer maintenance," B.S. computer science, SCSU. Now at Unisys Corp.

34. Judith Peters, in ASTR 323, B.S. physics, SCSU, M.S. Mechanical Engineering SCSU, LPKB Engineering.

35. Brent Williams, in ASTR 323, B.S. physics, SCSU, Ph.D. Univ. California Berkeley, Raymond R. Tucker Distinguished assistant professor at Washington University at St. Louis.

36. Megan Broberg, in ASTR 323, B.S. earth science, SCSU, now pursuing graduate studies.

37. Pete Crandall, in ASTR 323, SCSU, "CCD Observations of Comets," B.S. physics, product manager at TE Connectivity.

2001

38. Jeff Ward, “SHINY: linux laptops and image acquisition,” B.S. computer science, SCSU, 2004, Senior Software Engineer at Akamai Technologies.

39. Eric Richey, "CCD Observations of comets," computer science major, SCSU

40. Michelle Kawecki, "Observing Comets," physics major, SCSU

2003

41. Nicholas Johnson, in ASTR 311, “Planetary spectra,” B.S. computer science, 2004, SCSU

42. Laura Holt in ASTR 311, “Optical images of comets,” B.S. physics, 2004

43. Jesse Belschner in ASTR 311, “Optical images of comets,” B.S. physics, 2004. Now a medical physicist in Minnesota.

2004

44. Kyle Nestor, “Observing Comets,” B.S. aviation, 2006, SCSU, Captain, Challenger 300 at Harley-Davidson Motor Co.

45. Matt Gesmundo, “Observing comets” in ASTR 323, physics major, SCSU, B.S. electrical engineering 2007. Project engineer at Nortech systems.

46. Sung Yeol Choi, “Computer programming and data reduction,” computer science major, SCSU, B.S. computer engineering 2006, M.S. electrical and computer engineering, 2009, SaaS developer at Isola Group.

47. Todd Stanley, “Planetary spectroscopy with the SCSU Observatory” in ASTR 323, B.S. physics, 2005, now software engineer at Hysitron.

2005

48. Joshua Swanson, “Mm-wave spectra of comet C/2001 Q4 NEAT,” in ASTR 311, B.S. physics, 2007, SCSU. Ph.D. Univ. Wisconsin-Madison, postdoctoral researcher at Brown Univ; Engineer at Intel, Oregon.

49. Dan Hessler, in ASTR 311, “Optical spectra of Mars,” ASTR 311, physics, SCSU

2006

50. Tom Pundsack in ASTR 323, “Optical spectra of comets,” B.S. physics and math, 2007, SCSU. Ph.D. physics, Univ. Minnesota 2014; Instrument Specialist, Pace Analytical.

2008

51. Andy Davies in ASTR 311, “Spectra of Hot Jupiters,” and “Extragalactic origin of Gamma Ray Bursts” in ASTR 312, B.S. physics, astrophysics track, SCSU 2011, graduate student Univ. Rochester dept of physics.

52. Brody Fuchs, “Internal energy of Io,” in ASTR 311, B.S. physics major with astrophysics track, 2010, SCSU, now graduate student in Dept Atm Science, Colorado State Univ.

53. Eric Bye, “Detecting Exoplanets,” in ASTR 311, computer science major, SCSU

54. Nishu Karna, “Diversity of Comets” in ASTR 311 and “Auroral activity and sunspots” in ASTR 312, B.S. physics, 2010, SCSU, now graduate student at George Mason Univ.

2009

55. Tim Roettger in ASTR 312, “Orbits of Binary Stars and Extrasolar Planets Learning Activity,” majoring in physics, SCSU.

56. Judd Worley in ASTR 312, “Gravitational collapse of diffuse and dense molecular clouds,” physics teaching major, SCSU.

2010

57. Shannon Escoto, “Studies of Hale-Bopp’s lightcurve,” physics major, SCSU.

58. Thomas Erdahl, “Dust and CO in comet Hale-Bopp,” M.S. in statistics, SCSU.

Note: Did not work with students while at NSF from 2011-2015

2015

59. Kacper Wierzchos, “Millimeter-wavelength spectroscopy and optical photometry of comets,” applied physics doctoral student, USF.

60. Ryan Mack, “Measuring millimeter-wavelength spectra of comet Hale-Bopp,” dual physics and math undergraduate major, USF.

2016

61. Timothy Cox, “Comet Lightcurve Project phase angle analysis,” physics major, USF.

62. Isabel Rivera, “Comet Lightcurve Project phase angle analysis,” physics major, USF.

63. Nathan Lastra, “Comet Lightcurve Project time series analysis,” physics major, USF.

64. Anthony Curtis, “Comet Lightcurve Project time series analysis,” physics major, USF.

2017

65. Charles Mentzer, “Comet Lightcurve Project,” physics major, USF.

66. Nicholas Ruffini, “Comet Lightcurve Project,” physics major, USF.

67. Olga Harrington Pinto, “Studies of CO+CO2 in comets,” applied physics doctoral student, USF.

67. Chloe Jackson, “Comet Lightcurve Project,” physics major, USF.

2018

68. Sharlene Cruz Gonzalez, “Comet Lightcurve Project,” physics major, USF.