

# Curriculum Vitae for Ka Chun Yu

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## Professional Preparation

Center for Astrophysics & Space Astronomy, University of Colorado, Boulder; star formation postdoctoral research associate (2000–2001)

University of Colorado, Boulder, CO; Astrophysical, Planetary, & Atmospheric Sciences (Ph.D, 2000)

University of Arizona, Tucson, AZ; Astronomy and Physics double major (B.Sc, Magna Cum Laude, 1992)

## Appointments

May 2004–present:	Curator of Space Science	DMNS
Jan 2001–May 2004:	Scientific Visualization Developer and Interpreter	DMNS
1992–2000:	Research assistant, Center for Astrophysics & Space Astronomy	UC-Boulder
1994–1999:	Teaching assistant, APAS	UC-Boulder

## Awards

2005–2007	Co-PI, NSF REC 0529522, “Evaluating Astronomy Learning in Immersive Virtual Environments”	\$348,990
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## Recent Collaborators

Kamran Sahami (Metro. State College Denver), M.S. Nanda Kumar (CAUP, Portugal), Ralph Shuping (SOFIA/NASA Ames), Allen Bierbaum (Priority 5, Ames, IA), Patrick Hartling (Priority 5, Ames, IA), Carolina Cruz-Neira (Priority 5, Lafayette, LA), Kenji Williams (Remedy Arts, Inc.), Leslie Gaston (University of Colorado at Denver), Staffan Klashed (SCISS AB, Sweden), Jan Warnstam (SCISS AB, Sweden), Trace Reddell (University of Denver), Christopher Rahaim (Purdue University), Martin Storksdieck (Institute for Learning Innovation, Annapolis, MD), Tom Lucas (Tom Lucas Productions, NYC), Donna Cox (NCSA), Stuart Levy (NCSA), Robert Patterson (NCSA), Andrew Hamilton (Univ. of Colorado, Boulder), Nigel Jenkins (Nebulus Design), John Bally (Univ. of Colorado, Boulder), Bo Reipurth (IfA, Univ. of Hawaii), Debra Shepherd (NRAO).

## Scientific Research

### Astronomy Learning in Immersive Virtual Environments (ALIVE)

My current research interests are in discovering learning modes and optimal teaching strategies using immersive virtual environments (VEs). VEs are computer-generated, three-dimensional environments that can be navigated to provide multiple perspectives. Immersive VEs provide the additional benefit of surrounding a viewer with the simulated reality. My recently funded NSF grant for ALIVE seeks to evaluate the incorporation of VEs and immersive VEs into formal college astronomy education. This study uses interactive, real-time software that I helped to develop at DMNS. Astronomy class students at the Metropolitan State College of Denver (MSCD) are surveyed to determine what astronomical misconceptions they already possess. From these front-end evaluations, learning modules using VE simulations will be developed to supplement the introductory astronomy curriculum. In the experiment, pre-course,

post-course, and curriculum tests will be used to determine the efficacy of immersive visualizations presented at the Denver Museum of Nature & Science's (DMNS) Gates Planetarium versus the same visual simulations in non-immersive settings (i.e., shown on a flat screen in a normal classroom), as well as a control case using traditional classroom multimedia.

The work will enable a thorough understanding of the effectiveness of VEs and immersive VEs in formal astronomy education. Immersive virtual reality and VEs are known to have substantial benefits in education (Dede et al. 1999). Immersive VEs lead to increased presence, which improves attention, engagement, and retention of presented material (Lombard & Ditton 1997); and can even significantly improve spatial cognition in women (Tan et al. 2004). Although large-scale immersive digital theaters have the potential to educate millions, no formal evaluation of their role in astronomy education has been undertaken. Astronomical misconceptions appear in all demographic groups, including preservice educators (Trundle et al. 2002). Surveys of students from grade school through college show fundamental errors in astronomy understanding. Misconceptions about the seasons, phases of the moon, and eclipses are amongst the most difficult to displace through standard pedagogy (Bailey & Slater 2003). The most effective way to address spatial misconceptions is by the use of three-dimensional models (Keating et al. 2002). Because of DMNS' in-house astronomy simulation software, the Gates Planetarium is uniquely equipped to evaluate these issues.

### **Star Formation**

My thesis research involved the observational study of outflows from young stellar objects, by using a multi-wavelength approach to look at various aspects of the outflow phenomena. My work combined both single-dish and interferometric millimeter and sub-millimeter observations (which probe the colder molecular gas), with near-infrared  $v = 1-0 S(1)$   $H_2$  imaging and spectroscopy (which trace the interface between molecular flows and atomic winds and jets from the young star), and optical narrowband imaging and spectroscopy of Herbig-Haro objects. These combined data-sets allow us to probe regions with varying excitation conditions, and will allow us to construct more accurate models of outflow acceleration from young stars, molecular gas entrainment, and jet interactions with ambient cloud gas via shocks. The regions of low-mass star formation studied in my thesis are the 12–15 outflows and young stars in OMC-2/3 (Yu et al. 1997, Yu et al. 2000), and the Barnard 5 IRS 1 and IRS 3 flows (Yu et al. 1999). This work has revealed the locations of the  $H_2$  emission with respect to the molecular gas; provided support for bow shock entrainment models for the acceleration of CO bearing gas; showed evidence for  $H_2$  heating by a magnetic precursor or HH-object-induced fluorescence; and showed that many  $H_2$  knots can be described as bow shocks with forward and reverse shock line profiles.

In addition, comparisons of CO,  $H\alpha$ , and  $H_2$  structures within  $20''$  of the Barnard 5 IRS 1 source supports an outflow acceleration model where both a jet and a wide angle wind emanate from the YSO or accretion disk. CO filaments found parallel to the IRS 1 flow may trace magnetosonic perturbations excited by major mass loss episodes of IRS 1. Luminosity masses of the outflow lobes are derived using a new technique which corrects for the optical depth of the line at each velocity channel. A comparison of mass spectra of flows from this work as well as from other authors reveals possible differences in how low and high mass YSOs entrain ambient gas into outflows as they evolve. Finally the numbers of flows found in the observed clouds are consistent with the hypothesis that outflows can provide part of the turbulent support within molecular clouds. The efficiency of this pressure support however drops in the case of OMC-2/3 where the main cloud is a narrow ridge.

My other recent research includes observational studies of the W40  $H II$  region (in progress), jets around YSOs using NICMOS (Reipurth et al. 1999b, Reipurth et al. 2000a, Reipurth et al. 2000b), high mass star formation (Bally et al. 1998b, Shepherd et al. 2000), and survey work (Reipurth et al. 2004, Kumar et al. 2002).

### **Computer Graphics and Scientific Visualizations**

I have done extensive development work on real-time, interactive astronomy virtual environments and visualization software at the Denver Museum of Nature & Science (DMNS) for the Gates Planetarium. This includes being a lead developer and sole scientific programmer for Cosmic Atlas, a space flight simulator and full-dome show creation tool. I was also instrumental in designing and helping to build the

Cosmic Atlas Galaxy, a real-time simulation of the entire Milky Way galaxy. I was part of the creative staff that used Cosmic Atlas to build DMNS' first full-dome planetarium show, *Cosmic Journey*, and continue to be involved in full-dome planetarium show productions, including the NSF-funded *Black Holes: The Other Side of Infinity*. Currently I am working with SCISS AB (Sweden) to improve their Uniview software by migrating code and features from Cosmic Atlas.

I am a lead developer for the IMP (Immersive Model Presentation) panoramic image viewer at the Denver Museum of Nature & Science. Created for tiled, immersive digital theaters like the Gates Planetarium, the viewer is fully interactive; is scriptable; and can be used to display normal two-dimensional images, cylindrical panoramas, spherical panoramic "environment maps," and 3D models inside a interactive, navigable, virtual environment. The panoramic image viewer is intended to enable a wide variety of non-astronomy content for display within the Gates Planetarium's real-time projection system. Currently I am working with the Infiscape Corp. (Ames, IA) to create an open source version of IMP, now called vPresent, for commodity PC-based visualization clusters.

## Publications

### Refereed Papers

1. K. C. Yu, K. Williams, D. Neafus, L. Gaston, & G. Downing, 2007, "Gaia Journeys: A Museum-based Immersive Performance Exploration of the Earth," *International Journal of Digital Earth*, submitted.
2. K. C. Yu, T. Reddell, L. Gaston, & N. E. Jenkins, 2007, "Exploration of Astronomical Data in Digital Planetarium-based Musical Performances," *Leonardo Electronic Almanac*, submitted.
3. D. Neafus, & K. C. Yu, 2007, "Performing and Visual Arts, The Sciences: Visualization brings them together at the Gates Planetarium," *The Planetarian*, **36**(3), pp. 6–17.
4. K. C. Yu, M. Brownell, J. Schoemer, D. Neafus, T. Lucas, & Z. Zager, 2007, "Live Action Film Footage for an Astronomy Fulldome Show," *The Planetarian*, **36**(1), pp. 6–17, 86–87.
5. B. Reipurth, K. C. Yu, G. Moriarty-Schieven, J. Bally, C. Aspin, & S. Heathcote, 2004, "Deep Imaging Surveys of Star-forming Clouds. I. New Herbig-Haro Flows in NGC 2264," *Astron. J.*, **127**, pp. 1069–1080.
6. M. S. Nanda Kumar, B. G. Anandarao, & K. C. Yu, 2002, "Ongoing Star Formation Activity in the L1340 Dark Cloud," *Astron. J.*, **123**, pp. 2583–2589.
7. K. C. Yu, Y. Billawala, M. D. Smith, H. Butner, & J. Bally, 2001, "Erratum: A Multi-wavelength Study of Outflows in OMC-2/3," *Astron. J.*, **121**, p. 1214.
8. K. C. Yu, Y. Billawala, M. D. Smith, H. Butner, & J. Bally, 2000, "A Multi-wavelength Study of Outflows in OMC-2/3," *Astron. J.*, **120**, pp. 1974–2006.
9. B. Reipurth, K. C. Yu, S. Heathcote, J. Bally, & L. F. Rodríguez, 2000, "Hubble Space Telescope NICMOS Images of Herbig-Haro Energy Sources: [Fell] Jets and Binarity," *Astron. J.*, **120**, pp. 1449–1466.
10. D. S. Shepherd, K. C. Yu, J. Bally, & L. Testi, 2000, "A CO, <sup>13</sup>CO, C<sup>18</sup>O and C<sup>17</sup>O Interferometric and IR Imaging Study of the Luminous Young Outflow IRAS 20126," *Ap. J.*, **535**, pp. 833–846.
11. B. Reipurth, S. Heathcote, K. C. Yu, J. Bally, & L. F. Rodríguez, 2000, "Hubble Space Telescope NICMOS and WFPC2 Images of the HH 1 Jet: A Comparative Study," *Ap. J.*, **534**, pp. 317–323.
12. B. Reipurth, K. C. Yu, J. Bally, & L. F. Rodríguez, 1999, "Multiplicity of the HH 111 Jet Source: Hubble Space Telescope NICMOS Images and VLA Maps," *Astron. Astrophys.*, **352**, pp. L83–L86.
13. K. C. Yu, Y. Billawala, & J. Bally, 1999, "Parsec-scale CO and H<sub>2</sub> Jets in Barnard 5," *Astron. J.*, **118**, pp. 2940–2961.

14. J. Bally, K. C. Yu, J. Rayner, & H. Zinnecker, 1998, "Hubble Space Telescope WFPC2 Observations of the Young Bipolar HII Region S106," *Astron. J.*, **116**, pp. 1868–1881.
15. K. C. Yu, D. Devine, & J. Bally, 1997, "Shock-Excited H<sub>2</sub> Flows in OMC-2 and OMC-3," *Ap. J.*, **485**, pp. L45–L48.
16. K. C. Yu & J. Bally, 1996, "Extra-Solar Planet Detection at Infrared Wavelengths from the Earth," *JGR-Planets*, **101**, pp. 14843–14852.
17. Q. D. Wang & K. C. Yu, 1995, "Shadowing the Soft X-ray Background by Infrared Cirrus: A Study of Selected Regions," *Astron. J.*, **109**, pp. 698–708.

#### **Refereed Conference Proceedings**

1. K. C. Yu, K. Williams, D. Neafus, L. Gaston, & G. Downing, 2007, "Gaia Journeys: A Museum-based Immersive Performance Exploration of the Earth," *Proceedings of the 5th International Symposium on Digital Earth*, June 5-9, 2007, Berkeley, CA.

#### **Invited Papers**

1. K. C. Yu, September 2005, "Digital Full-Domes: The Future of Virtual Astronomy Education," *The Planetarian*, **34**(3), pp. 6-11.

#### **Posters, Evaluations, and Other Unrefereed Publications**

1. K. C. Yu, 2008, "Future directions for research: Media aesthetics and fulldome filmmaking," *Fulldome Summit Proceedings*, 2008 Fulldome Summit, Chicago, Illinois, July 3, 2008, in press
2. K. C. Yu, 2008, "Fulldome Planetariums for Immersive Virtual Astronomy Education," *International Planetarium Society Proceedings*, 2008 IPS Meeting, Chicago, Illinois, June 27–July 2, 2008, in press
3. K. C. Yu, 2008, "Future directions for research: Media aesthetics and fulldome filmmaking," *Fulldome Summit Proceedings*
4. K. C. Yu, & K. Sahami, 2007, "Digital Planetariums for Astronomy Education," *ASTC Dimensions*, November/December 2007, pp. 11–12
5. K. C. Yu, & K. Sahami, 2007, "Visuospatial Astronomy Education in Immersive Digital Planetariums," *Communicating Astronomy with the Public 2007 Proceedings*, L. L. Christensen, M. Zoulias, I. Robson (Eds.), pp. 242-245
6. K. C. Yu, & K. Sahami, 2007, "Astronomy Learning in Immersive Virtual Environments," poster, Astronomical Society of the Pacific meeting, Sep 5–7, 2007, Chicago, IL.
7. K. C. Yu, & K. Sahami, 2006, "The ALIVE Project: Astronomy Learning in Immersive Virtual Environments," poster, Research and Evaluation on Education in Science and Engineering PI meeting, 2006 meeting, Dec 7–8, 2006, Washington, DC.
8. M. Storksdieck, & K. C. Yu, 2006, "Meta!Blast Front-End Visitor Survey: Summary of Results," Institute for Learning innovation & Denver Museum of Nature & Science, 6 pp.
9. K. C. Yu, 2005, "Lecture Notes for Introduction to Cosmology," for a Lifelong Learning class held Oct, 2005, DMNS Technical Report 2005-12, 167 pp.
10. K. C. Yu, 2005, "Lecture Notes for Introduction to Astronomy," for a Lifelong Learning class held Sept–Nov, 2004, DMNS Technical Report 2005-10, 216 pp.
11. K. C. Yu & N. E. Jenkins, 2004, "Cosmic Atlas: A Real-Time Universe Simulation," 204th AAS Meeting, #78.04, *Bull. Am. Astron. Soc.*, **36**, pp. 809–810.

12. K. C. Yu, 2001, "Hot and Cold: A Study of H<sub>2</sub> Jets and CO Molecular Outflows from Young Stars," 197th AAS Meeting, #29.03, *Bull. Am. Astron. Soc.*, **32**, p. 1445.
13. K. C. Yu, 1999, "High Resolution Spectroscopy of Shocked H<sub>2</sub> from Stellar Outflows," 195th AAS Meeting, #135.05, *Bull. Am. Astron. Soc.*, **32**, p. 883
14. K. C. Yu, Y. Billawala, J. Bally, & D. Devine, 1998, "A Multi-Wavelength Study of Outflows in OMC-2/3," 192nd AAS Meeting, #10.08, *Bull. Am. Astron. Soc.*, **30**, p. 829.
15. D. S. Theil, K. C. Yu, & J. Bally, 1995, "Cometary Globules in the Orion Super-Bubble," in *CO: Twenty-five Years of Millimeter-wave Spectroscopy Poster Sessions*, IAU 170.
16. K. C. Yu, J. Bally, M. Hereld, & B. J. Rauscher, 1995, "Molecular Shocks in the L1228 Cloud Core," 187th AAS Meeting, #21.13, *Bull. Am. Astron. Soc.*, **27**, p. 1319.
17. N. M. Schneider, D. E. Shemansky, & K. C. Yu, 1989, "Search for [O I] 6300 Å Emission from Io," *Bull. Am. Astron. Soc.*, **21**, p. 988.

## Professional Talks/Presentations

- July 1, 2008 "FullDome Planetariums for Immersive Virtual Astronomy Education," IPS workshop, Adler Planetarium, Chicago, IL
- July 1, 2008 "Astronomical Data Standards," IPS panel, Adler Planetarium, Chicago, IL
- July 1, 2008 "Real Time Scaling of Real Time Data for Real Time Teaching and Learning – planetariums as immersive learning labs," IPS panel, Adler Planetarium, Chicago, IL
- Mar 26, 2008 *Media Aesthetics for FullDome Filmmaking (II)*, Immersive Cinema Workshop, Plymouth, UK
- Mar 27, 2008 *vPresent: A New Open Source Presentation Tool for Immersive Environments*, Immersive Cinema Workshop, Plymouth, UK
- Mar 26, 2008 *Media Aesthetics for FullDome Filmmaking (II)*, Immersive Cinema Workshop, Plymouth, UK
- Oct 10, 2007 *Gates Planetarium: At the Four Year Mark and Beyond*, Hamburg Planetarium, Hamburg, Germany
- Oct 10, 2007 *Visuospatial Astronomy Education in Immersive Digital Planetariums*, Communicating Astronomy with the Public 2007, Athens, Greece
- Sep 4, 2007 *Beyond Lasers: Scientific Visualizations for Multimedia Art Experiences in Digital Planetaria*, Astronomy Visualization Workshop 2007, Chicago, IL
- Jul 21, 2007 *Media Aesthetics for FullDome Filmmaking*, Domefest 2007, Albuquerque, NM
- Jul 4, 2007 *Astronomy Learning in Immersive Virtual Environments*, Gordon Research Conference on Scientific Visualization for Education, Bryant University, RI
- Nov 8, 2006 *Procedural Noise Techniques for Astronomical Renderings*, Astro-Viz '06, Pasadena, CA
- Nov 8, 2006 *Planetarium Production Stories: Live Action Film Footage for a FullDome Show*, Astro-Viz '06, Pasadena, CA
- Oct 29, 2006 *Understanding the Audience Potential of FullDome Digital Video*, panel member, Association of Science & Technology Centers, Louisville, KY
- Sep 17, 2006 *Black Holes: The Other Side of Infinity* full-dome clip introduction, 118th Astronomical Society of the Pacific, Baltimore
- Sep 8, 2005 Western Alliance Conference of Planetariums, DMNS
- May 26, 2005 Visualization of Astrophysical Data conference, Univ. of Chicago
- Apr 14, 2005 Lockheed Martin Solar Physics group, Sunnyvale, CA
- Apr 14, 2005 SOFIA science & engineering team, NASA Ames, CA
- Aug 2001 NASA Ames, Moffett Field, CA
- Aug 2001 JPL, Pasadena, CA
- Aug 2001 UCLA, Los Angeles, CA
- Jan 2001 AAS Meeting #197, San Diego, CA

- May 2000 NRAO, Socorro, NM
- Nov 1999 CfA, Cambridge, MA
- Apr 1999 Caltech, Pasadena, CA
- Mar 1999 NOAO, Tucson, AZ

## Public Talks, Performances, Appearances, and Classes

- June 2004–present Monthly talk, “60 Minutes in Space,” DMNS
- July 9, 2008 Uniview flight for COGA talk with Bob Reynolds, Gates Planetarium, DMNS
- July 9, 2008 “Astrophysical Visualizations for Digital Planetariums,” Curator’s Lunchtime Talk, Ricketson Auditorium, DMNS
- June 20, 2008 “Astronomy Learning in Immersive Virtual Environments,” ALIVE Open House, DMNS
- July 19, 2008 Uniview flight for “Weird Moons” talk with John Spencer, Gates Planetarium, DMNS
- June 16, 2008 “Hubble Space Telescope Discovery Workshop V: Data Reduction and Color Image Compositing,” Galaxy Guide volunteer training, DMNS
- June 13, 2008 “Virtual Astronomy from the Ground Up,” talk for Dine teachers, Ricketson Auditorium, DMNS
- June 11, 2008 “Geography Goes Digital III,” talk with Bob Reynolds, Gates Planetarium, DMNS
- May 22, 2008 “Geography Goes Digital II,” talk with Bob Reynolds, Gates Planetarium, DMNS
- May 19, 2008 “Hubble Space Telescope Discovery Workshop IV: Hubble Key Project,” Galaxy Guide volunteer training, DMNS
- May 12, 2008 “Hubble Space Telescope Discovery Workshop III: V838 Mon and SN 1987A,” Galaxy Guide volunteer training, DMNS
- May 5, 2008 “Hubble Space Telescope Discovery Workshop II: Proplyds and Star Formation in Orion,” Galaxy Guide volunteer training, DMNS
- April 21, 2008 “Full-dome Planetariums for Astronomy Instruction,” talk at Global Immersion Workshop, Gates Planetarium, DMNS
- April 21, 2008 Uniview flight for “Astrobiology” talk with David Grinspoon at Global Immersion Workshop, Gates Planetarium, DMNS
- April 16, 2008 “Geography Goes Digital I,” talk with Bob Reynolds, Gates Planetarium, DMNS
- April 14, 2008 “Hubble Space Telescope Discovery Workshop I: Introduction,” Galaxy Guide volunteer training, DMNS
- April 10, 2008 “Adventures in Planetariums, Outreach and Other Things,” lecture to Astro 4010 Astrophysics Research seminar, T. Snow, University of Colorado at Boulder
- February 5, 2008 “Dark Energy in the Universe,” talk for Golden High School senior seminar
- January 14, 17, 2008 “Knowing Your Audience: Astronomy Misconceptions by the Public,” talk and discussion with Galaxy Guide volunteers, DMNS
- October 29–30, 2007 “Geospatial Data Presentations in Planetariums,” demonstrations for Geological Society of America conference attendees, Gates Planetarium, DMNS
- August 4, 2007 “Hubble Space Telescope Discovery Workshop,” one-day class, DMNS
- August 2, 2007 “Dark Energy in the Universe,” *Mixed Taste* talk at the Belmar Laboratory for Art and Ideas, Lakewood, CO
- July 13–15, 2007 DMNS Colorado River Stargazing canoe trip lecturer, Colorado River, CO
- June 26, 2007 *Richard Pinhas, Antoine Paganotti, and Jerome Schmidt* multimedia performance, Gates Planetarium, DMNS
- June 20, 2007 “Astronomy Learning in Immersive Virtual Environments,” Lunchtime curator talk, DMNS
- May 11, 2007 “Astronomy Learning in Immersive Virtual Environments,” ALIVE Open House, DMNS
- May 3, 2007 “Dark Energy,” Space Day lecture, DMNS
- May 3, 2007 Discussion panel member for Astro 4010, Astrophysics Research seminar, T. Snow, University of Colorado at Boulder

- April 30, 2007 Planetarium star talk and lecture for Colorado School of Mines, Gates Planetarium, DMNS
- April 20, 2007 "Evening in Space" star talk and lecture, Gates Planetarium, DMNS
- April 17, 2007 Planetarium star talk and lecture for CCD ACES class, Gates Planetarium, DMNS
- April 16, 2007 Planetarium star talk and lecture for 1st grade class, Gates Planetarium, DMNS
- March 20, 2007 "Cosmological Origins," Volunteer Enrichment Committee brownbag lunch lecture, DMNS
- March 13, 2007 "Cosmological Origins: The Universe, Galaxies, and Stars," Volunteer Enrichment Committee lecture, DMNS
- March 12, 2007 "An Evening in Space" star talk and lecture, Gates Planetarium, DMNS
- March 5, 2007 "An Evening in Space" star talk and lecture, Gates Planetarium, DMNS
- February 15–18, 2007 *Gaia Journeys* multimedia performance with Kenji Williams, Gates Planetarium, DMNS
- January 11, 2007 "Real-time Uniview Demonstration" star talk and lecture for Hewlett-Packard, Gates Planetarium, DMNS
- November 13, 2007 Planetarium star talk and lecture for Hewlett-Packard/Intel's Quad Fest, Gates Planetarium, DMNS
- August 11–13, 2006 DMNS Perseids Meteor Shower canoe trip lecturer, Gunnison River, CO
- August 9, 2006 "A Short History of Immersive Art," Lunchtime curator talk, DMNS
- June 3, 2006 "What Do I Do as a Scientist?" talk for Project Curiosity Teacher's Workshop, DMNS
- April 20, 2006 "The Astrophysics of *Black Holes: The Other Side of Infinity*," for "Third Thursday" Galaxy Guide talk, DMNS
- April 3, 2006 "Updates in Space Science" talk for LUMC Optimist Club, Littleton
- March 9, 2006 "Updates in Astronomy," talk for Sertoma, Englewood
- March 4, 2006 "The Astrophysics of *Black Holes: The Other Side of Infinity*" talk for "It's All Relative" Teacher's Workshop, DMNS
- January 19, 2006 K. Powell, "Dream big," *Nature*, 439, pp. 364–365
- October, 2005 "Introduction to Cosmology," four session class, DMNS
- October 25, 2005 Talk to Discover Plasma Science Teachers Day workshop, Denver, CO
- August 13, 2005 Talk to Solar Physics and Space Weather teachers' workshop, DMNS
- August 8, 2005 TV appearance, Channel 2 News, Denver, CO
- June 22, 2005 Radio interview, KOA, Denver, CO
- June 9, 2005 Talk to Ft. Collins Discovery Center teachers, DMNS
- June 6, 2005 Constellation talk to DMNS Outreach teachers
- May 10, 2005 TV appearance, "Colorado and Company," Channel 9, Denver, CO
- April 9, 2005 Star talk to All-Sky camp-in group
- March 15, 2005 Talk to Cub Scout Pack 79, Denver, CO
- January 26, 2005 Lunchtime curator talk, DMNS
- November 23, 2004 Talk to Science Matters teachers' workshop, Littleton, CO
- October 23, 2004 Astronomy Day talk, DMNS
- September–November, 2004 "Introduction to Astronomy," six session class, DMNS
- August 5 2004 Talk to Astrobiology: Life in Space teachers' workshop, DMNS
- October 2000 AIAA (University of Colorado chapter), Boulder, CO
- September 2000 Denver Astronomical Society, Denver, CO

## Planetarium Shows and Other Visualizations

1. Graphic for article, "Who Speaks for Earth?" by D. Grinspoon, *Seed Magazine*, November/December 2007.
2. *Cosmic Journey (III)*, Denver Museum of Nature & Science, October 2007.
3. *Black Holes: The Other Side of Infinity*, Denver Museum of Nature & Science, February 2006.
4. *Cosmic Journey (II)*, Denver Museum of Nature & Science, Jan 2004.

5. *Cosmic Journey*, Denver Museum of Nature & Science, July 2003.

## **Reviews**

1. January 2008, NOAA Science on a Sphere Review Panel
2. November 2007, Reviewer for 3rd International Symposium on Visual Computing (ISVC07) [G. Bebis et al. (Eds.), *Advances in Visual Computing, Parts I & II*, Berlin: Springer]

## **Software Projects**

1. Cosmic Atlas (2001–2004)
2. Cosmic Atlas Galaxy Flythrough (2003–2004)
3. IMAGE\_PAN / IMP (2003–2005)
4. vPresent (2007–present)

## Observing Proposals Granted Time

1. IRTF, 2 nights, Summer 2006 (co-I)
2. Lick Observatory, 2 nights, Fall 2001 (co-I)
3. Calar Alto, 2 nights, Summer 2001 (PI)
4. FCRAO, Spring 2001 (co-I)
5. VLA, 8 h, April 2000 (PI)
6. SMTO HHT, 32 h, Fall 1999–Spring 2000 (PI)
7. OVRO, 5 tracks, April 1999 (co-I)
8. SMTO HHT, 50 h, March 1999 (PI)
9. OVRO, 8 tracks, May 1998 (co-I)
10. HST, NICMOS2, 15 orbits, Cycle 7 (co-I)
11. KPNO 4 m, Phoenix (NIR spectrograph), 3 nights, November 1997 (PI)
12. CTIO 1.5 m, CIRIM (NIR imager), 6 nights, February 1997 (PI)
13. KPNO 2.1 m, IRIM (NIR imager), 5 nights, November 1996 (PI)
14. CTIO 1.5 m, CIRIM (NIR imager), 4 nights, April 1996 (PI)
15. Apache Point 3.5 m, GRIM II (NIR imager), 4 nights, January 1996 (co-I)

## Technical Skills

My visualization work at DMNS have involved a variety of scientific and 3D real-time programming projects written in C and using SGI's Performer OpenGL API:

- Cosmic Atlas: Writing new as well as converting pre-existing code for orrery functions (both database lookup, analytical functions, and solving Kepler's equation); loading and manipulating astronomical databases; designing a highly realistic Milky Way galaxy model taking into account different stellar spectral classes, interstellar reddening, dust and molecular cloud distributions, clumping of structure using procedural noise techniques, integrating real catalog data, and disk, bulge, and halo star populations.
- Developing the beta version of the Immersive Model Presentation (IMP) Viewer software for real-time visual data display.

My observing experience is predominantly in the near-infrared, particularly the  $v = 1-0 S(1) \text{H}_2$  line in the  $K$  band in imaging as well as spectroscopy (Apache Point, Kitt Peak 2.1 m, Cerro-Tololo Inter-American Observatory 1.5 m, Palomar 60", Kitt Peak Mayall 4 m). Other past data reduction and analyses include WFPC2 and NICMOS imaging from HST (including extensive imaging processing using dithering and Lucy-Richardson deconvolution techniques); single-dish radio telescopes in the sub-millimeter (SMTO Heinrich Hertz Telescope) and sub-millimeter and radio interferometers (OVRO, VLA); and a large number of observations by collaborators including optical and near-infrared spectroscopy and imaging (RCSPEC and T2KA on the Kitt Peak 0.9 m, 4 m; CSHELL at the NASA IRTF; MOSAIC images from the Kitt Peak 0.9 m and 4 m) and sub-millimeter spectroscopy ( $^{12}\text{CO } J = 2 \rightarrow 1$  maps from the NRAO 12 m;  $^{12}\text{CO}$  and  $^{13}\text{CO}$  maps from the Bell Labs 7 m).

In previous non-thesis related research (Wang & Yu 1995), I reduced and analyzed ROSAT PSPC data pertaining to the soft X-ray background. I have modified Erich Grossmann's AT atmospheric transmissivity code to include Doppler broadening in its calculated line profiles.

The majority of the data reduction and analysis for the above observations were accomplished via IRAF routines and personal software written in IDL. Limited familiarity was made for the MMA, MIRIAD, CLASS, GILDAS, GREG, and AIPS software packages.

## **Computer Skills**

**Programming Experience:** IDL (10+ yrs) with emphasis on image processing; HTML (7+ yrs); building and managing WWW sites (6 yrs), including use of CGI scripts (4+ yrs); LaTeX (12+ yrs), TeX (7+ yrs); X-windows (12+ yrs), Perl (5+ yrs), UNIX shell scripts (4+ yrs); C (5+ yrs), Performer OpenGL (< 2 yr), Javascript (< 3 yrs), IRAF command language (< 3 yrs), sed (< 2 yr); awk (< 2 yr); FORTRAN (3+ yr); JAVA 2 (1 yr; includes Sun Microsystems Java Programming Language training course SL-275).

**Operating System Experience:** UNIX SunOS and Solaris (13+ yrs), Ubuntu 7.04, 7.10, 8.04 (2+ years), Redhat Linux 6.2, 7.2, 7.3, 8.0 (5+ yrs), SuSE 9.2, 9.3 (2+ yrs), UNIX IRIX (3+ yrs), UNIX AIX (< 1 yr), UNIX Ultrix (< 1 yr); Macintosh OS (16 yrs); Microsoft Windows XP (5 yrs).

**Multimedia & Graphics Design:** Adobe Photoshop (7+ yrs), Adobe Illustrator (6+ yrs), Gimp (4+ yrs), AliasWavefront Maya (1+ yr), Macromedia Director (< 1 yr).