Advanced Technologies and Instrumentation at the National Science Foundation

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Astronomy & Astrophysics Advisory Committee (AAAC) Meeting
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ATI through the years

• 1980’s: Charge Coupled Devices

• 1990’s:
  – Sub-millimeter astronomy
  – Adaptive optics

• 2000’s:
  – IR detectors
  – Instrumentation (eg. KPNO, Palomar, CSO…)

• 2010’s:
  – Radio/submm focal plane arrays; low frequency
  – Laser frequency combs (HPRV)
What is the *impact* of ATI?

Acknowledgements comparable to Planetary Astronomy (PLA)

| Acknowledgements in peer-reviewed literature | PLA   | ATI   |
|----------------------------------------------|-------|-------|
| Total number of awards (1987 – 2016)         | 445   | 496   |
| Acknowledged at least once                   | 138   | 216   |
| Acknowledged at least twice                  | 83    | 140   |
| Acknowledged at least 5x                     | 35    | 51    |
| Acknowledged at least 10x                    | 16    | 18    |
| Acknowledged at least 20x                    | 3     | 3     |

Kurczynski & Neff 2018, SPIE 10706 (arxiv: 1809.01294)
ATI has comparable impact to PLA

Figures courtesy Stasa Milojevic, Indiana University

Kurczynski et al 2019 in prep
"That original ATI grant was enabling for LSST. I don’t think we would have a camera now without it."

-Tony Tyson
IR Multi-Object Spectroscopy (1997 PI: Elston)

| Instrument  | Facility          | 1st Light |
|-------------|-------------------|-----------|
| FLAMINGOS   | KPNO/Gemini       | 2000      |
| MOIRCS      | Subaru            | 2004      |
| MMIRS       | Magellan/MMT      | 2009      |
| LUCIFER     | LBT               | 2009      |
| Flamingos2  | Gemini            | 2010      |
| MOSFIRE     | Keck              | 2012      |
| KMOS        | VLT               | 2012      |
| EMIR        | GTC               | 2016      |
EDGES – Evidence of the First Stars

Bowman, J. et al Nature 2018

EDGES media coverage

- Video: 109,000 views on YouTube
- Washington Post
- NY Times
- USA Today
- CNN
- The Guardian (UK)
- Physics World Breakthrough of the Year 2018 (Finalist)

Awaiting confirmation...
Event Horizon Telescope

Science breakthrough of the year in 2019?
– Forbes Magazine

- 22 NSF awards (2000-2018)
- $29M NSF investment
- 8 ATI awards ($8M)
Conclusions

• ATI: 30+ years of science & technology awards
• Literature impact comparable to pure science program
• It may take a decade or more to know the true impact of technology development in astronomy
• ATI solicitation now active!

Acknowledgements & Image Credits

Images: Magellan Clay: Ian Czekalav (astrobites); Subaru, LBT, Keck, VLT, Gemini, GTC: Wikipedia; FLAMINGOS at KPNO: Elston+2003; MOIRCS Suzuki+2008; MMIRS McLeod+2012; LUCIFER Seifert+2002; MOSFIRE Mclean+2010; KMOS Sharples+2006; EMIR Garzon+2006. Priv. communications: Christoph Baranec, Jamie Bock, Julian Christou, Mark Chun, Kieran Cleary, Scott Diddams, Shep Doeleman, Steve Eikenberry, Neal Erickson, Shaul Hanany, Don Figer, Debra Fischer, Jian Ge, Phil Goode, Don Hall, Gregg Hallinan, Casey Law, Mike Pierce, Deqing Ren, Tony Readhead, Ray Sharples, Tony Tyson, Melville Ulmer
EXTRA SLIDES
Summary of Active Awards*

- Radio-optical wavebands
- Broad science & technology focus
- ~$8M / year budget

*includes FY17
Advanced Technologies & Instrumentation

- 54 active awards / $41.6M
- FY17: 9 projects / 1 conference awarded ($5.7M)
- ATI Budget: ~$8M / yr

AAG Funding History, 1990-2016

- Projecting ~$47M for FY 2017

AAG Budget, $M

[Bar chart showing funding history from 1990 to 2016, with projected funding for 2017.]
Universality of science citations

Fortunato et al. 2018, Science 359, 1007; Fig 5A
ATI: Citations of most-cited-papers

| Program | Median |
|---------|--------|
| ATI     | 39     |
| SPG     | 21     |
# Impact of most-cited papers

| Award (1) | PI (2)       | Bibcode (3) ATI | Year (4) | Citations (5) | Median (6) | Impact (7) |
|-----------|--------------|-----------------|----------|----------------|-------------|------------|
| 9413935   | Readhead     | 2002ApJ...568...38H | 2002     | 769           | 36          | 21.4       |
| 0096913   | Carlstrom    | 2002ARA&A..40..643C | 2002     | 561           | 36          | 15.6       |
| 8822465   | McCarthy     | 1991ApJS...77..417K | 1991     | 495           | 25          | 19.8       |
| 0904607   | Townsend     | 2013ApJS..208....4P | 2013     | 489           | 9*          | 54.3*      |
| 9203336   | McCarthy     | 1993AJ....106..773H | 1993     | 420           | 27          | 15.6       |
| 9120599   | Begelman     | 1994ApJ...421..153S | 1994     | 860           | 27          | 31.9       |
| 8857365   | Wisdom       | 1991AJ....102.1528W | 1991     | 675           | 25          | 27.0       |
| 9530590   | Heiles       | 2003ApJ...586.1067H | 2003     | 341           | 28          | 12.2       |
| 9973057   | Tedesco      | 2002AJ....123.1056T | 2002     | 310           | 36          | 8.6        |
| 9714275   | Lin          | 2001ApJ...548..466B | 2001     | 249           | 31          | 8.0        |

**PLA**

| Award (1) | PI (2)       | Bibcode (3) PLA | Year (4) | Citations (5) | Median (6) | Impact (7) |
|-----------|--------------|-----------------|----------|----------------|-------------|------------|
| 9120599   | Begelman     | 1994ApJ...421..153S | 1994     | 860           | 27          | 31.9       |
| 8857365   | Wisdom       | 1991AJ....102.1528W | 1991     | 675           | 25          | 27.0       |
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Astronomical Sciences
Limits of literature assessment

- **Type I error (false positive):** <15%
  - from individual inspection of 33/216 most cited ATI publications.
  - No false positives found.
- **Type II error (false negative):**
  - non-ADS publications: not in ADS database (automated search)
  - delinquent publications: do not (fully) acknowledge award
Limits of literature assessment …

- Widely acknowledged awards may be impactful
- Impactful awards may not be widely acknowledged

| Award ID  | PI                        | Acknowl. | Most Cited                  | Citations |
|-----------|---------------------------|----------|-----------------------------|-----------|
| 0906060   | Baranec, Christoph        | 31       | 2014ApJ...791...35L         | 79        |
| 0705139   | Ge, Jian                  | 27       | 2011ApJ...728...32L         | 29        |
| 1006676   | Mahadevan, Suvrath        | 22       | 2014Sci...345..440R        | 68        |
| 9731180   | Elston, Richard           | 5        | 2003AJ....125.2029M        | 112       |
| 0441069   | Tyson, J. Anthony         | 1        | 2014JInst...9C7010T        | 0         |

* Number of peer-reviewed publications that acknowledge this award
ATI trains instrument builders

• Award size and scope
  – Large enough to have substantial impact
  – Small enough for early-career investigator

• Awardees become leaders
  – PECASE and CAREER awardees
  – Large projects
ATI Program: current status

- Program currently on hold
- New solicitation in progress
- Expected return in FY19

- Joint NSF/NASA Principal Investigators meeting
  - planned for September 2018
  - Active ATI investigators: See me for details!

- See here for program info:
  https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5660
Limits of literature assessment ...

- Widely acknowledged awards may be impactful
- Impactful awards may not be widely acknowledged

| Award ID | Principal Investigator      | Ackn.* |
|----------|-----------------------------|--------|
| 0906060  | Baranec, Christoph          | 31     |
| 0705139  | Ge, Jian                    | 27     |
| 1006676  | Mahadevan, Suvrath          | 22     |
| 9731180  | Elston, Richard             | 5      |
| 0441069  | Tyson, J. Anthony           | 1      |

* Number of peer-reviewed publications that acknowledge this award
Multi-Conjugate Adaptive Optics (MCAO)

- MCAO under development at Big Bear Solar Observatory (BBSO)
- Uses 3 deformable mirrors to compensate for turbulence at 3 different heights in the atmosphere
- NSO personnel leading the effort
- NSF funded through AST-ATI award
- Pathfinder for DKIST next-generation AO system
What is the impact of ATI?

- automated search for grant acknowledgement in ADS
- compare with planetary astronomy program (PLA)

| Acknowledgments | ATI (2) | PLA (3) |
|-----------------|---------|---------|
| 20              | 3       | 3       |
| 10              | 18      | 16      |
| 5               | 51      | 35      |
| 2               | 140     | 83      |
| 1               | 216     | 138     |
| Total           | 496     | 445     |

Kurczynski & Neff 2018 SPIE (arxiv:xxx)
Case study: LSST detectors (2004 Award PI: Tyson)

- detector design study; 1st NSF award for LSST
- crucial time in project development

“That original ATI grant was enabling for LSST. I don’t think we would have a camera now without it.”

-Tony Tyson