

Nicholas M. Law

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Research Interests: Exoplanets, wide-field surveys, very-low-mass stars, astronomical instrumentation, adaptive optics, high-speed astronomy

EMPLOYMENT

July 2006+ **Postdoctoral Scholar in Astronomy**, California Institute of Technology

Project Scientist for the Palomar Transient Factory fast transient search program

Principal Investigator for the MAAPS M-dwarf Astrometric AO Planet Search

Principal Investigator for the LAMP visible-light AO instrument

(one of Time Magazine's Best Inventions of 2007)

Project Scientist for the CAMERA low-cost laser guide star adaptive optics system

Project Scientist for the FastVis Keck high-speed visible-light spectrograph

EDUCATION

Oct. 2003 – June 2006:

Ph.D. Astronomy

University of Cambridge, Cambridge, UK

Thesis: Lucky Imaging: Diffraction-limited Astronomy from the Ground in the Visible.

Advisor: Dr Craig Mackay

Prizes and awards: PPARC Studentship, Corfield Scholarship

Oct. 2002 – Oct 2003:

MSci Physics

University of Cambridge, Cambridge, UK (Selwyn college)

Prizes and awards: Selwyn Prize for Physics & Tripos Prize

Oct. 1999 – July 2002:

BA Physics

University of Cambridge, Cambridge, UK (Selwyn college)

PROFESSIONAL SERVICE

September 2008 Caltech Palomar and Keck 2008B Time Allocation Committee

August 2008 Co-chaired a 3-day Palomar Transient Factory Science Workshop at KITP

March 2008 Caltech Palomar and Keck 2008A Time Allocation Committee

OBSERVING TIME GRANTED AS PI

2009 “LGS AO Close companions in very wide, VLM binaries”	2 nights, Keck II
2009 “Sub-Jupiter-Mass Planets [MAAPS]”	6 nights, Palomar 200”
2008 “Sub-Jupiter-Mass Planets [MAAPS]”	8 nights, Palomar 200”
2008 “LGS AO Close companions in very wide, VLM binaries”	1 night, Keck II
2008 “Binaries on the Very Low Mass / Low Mass Transition”	5 nights, ESO NTT
2008 “Southern Exoplanet Targets”	3 nights, ESO NTT
2007 “Binaries on the Very Low Mass / Low Mass Transition”	3 nights, Palomar 200”
2007 “Outflows and Bipolar Jets from Symbiotic Binaries”	2 nights, Palomar 200”
2006 “Southern Very Low Mass Binaries”	3 nights, ESO NTT
2005 “Companions to field VLM binaries”	5 nights, NOT (La Palma)

SUCCESSFUL GRANT HISTORY

- 2008 SIM Science Study (co-I): “M-dwarfs: is SIM competitive?”
- 2008 Keck phase-one instrument study (project scientist): “FastVis high-speed spectroscopy”

CONFERENCE & SEMINAR PRESENTATIONS

August 2008	Palomar Transient Factory Science Workshop: PTF Project Overview
August 2008	Palomar Transient Factory Science Workshop: Microlensing Events in PTF
June 2008	SPIE Astr. Telescopes & Instrumentation: CAMERA: Low Cost LGS AO
March 2008	Pasadena Postdoc retreat: New Visible-Light AO Systems at Palomar
January 2008	AAS: Getting Lucky With Adaptive Optics
December 2007	JPL Astronomy Talk: Getting Lucky at Palomar: 2X HST Resolution
January 2007	AAS: The SIM Tier-2 Terrestrial Planet Survey
November 2007	Caltech Tea Talk: Getting Lucky at Palomar: 2X HST Resolution in the Visible
March 2007	CfAO Adaptive Optics Workshop: The LAMP Lucky+AO instrument
October 2007	Ringberg Adaptive Optics Workshop: 2X HST Resolution in the Visible
October 2006	JPL Astronomy Talk: Lucky Imaging
March 2006	Caltech Tea Talk: Lucky Imaging

PUBLIC OUTREACH ACTIVITIES

July 2008	So. California Astronomy Exposition: Beating the Hubble from Earth (invited talk)
March 2008	Friends of Palomar talk: Taking the Twinkle Away: Adaptive Optics at Palomar

TEACHING EXPERIENCE

2008	Mentor for Wojciech Makowiecki (summer undergraduate research)
2007	Co-mentor for Lothar Ratschbacher & Dan Beeler (summer undergrad research)
2003-2005	Supervisor (tutor) for Cambridge undergraduate physics courses

CURRENT MAJOR RESEARCH AREAS

Palomar Transient Factory (Project Scientist)

PTF is a new wide field, multiple cadence transient survey, for which I am Project Scientist. The survey is based on a 12Kx8K, 7.8 square degree CCD array newly placed on the 48" Oshin Telescope at Palomar Observatory. PTF uses 80% of the 48" telescope time and will reach a depth of $r=21$ in the

nominal 60-second exposures. Two major experiments are planned: 1/ a 5-day cadence supernova search and 2/ an exotic transient search with cadences between 90 seconds and 1 day. In addition, an all-sky H-alpha survey will be conducted during full-moon nights and a winter month will be spent in a single field searching for eclipsing stars and transiting planets around young solar-mass stars. PTF will provide automatic, realtime transient classification and followup, as well as a huge database including every source detected in each frame with photometric precision at the few-percent level. The survey is a collaboration involving 45 people from Caltech, IPAC, LBL, Berkeley, Columbia, LCOGT and the Weizmann Institute.

Full PTF science operations are planned to start in early 2009. My particular PTF science interests are to search for M-dwarf planetary transits in the general survey fields.

Astrometric M-dwarf Planet Search (PI)

I have started a new major astrometric program (MAAPS; the M-dwarf Astrometric AO Planet Survey) at Palomar to search for Jupiter-mass planets using the P200 adaptive optics system to achieve 100-200 microarcsecond precision, accuracy and stability. This level of astrometric precision is possible by: (1) controlling systematic effects (distortion, refraction) through careful experimental design, (2) proper accounting for atmospheric and measurement statistics to construct a detailed covariance matrix for position measurement, and (3) the use of an optimal estimation algorithm to combine measurements to calculate high-precision stellar positions. Targeting mid-M-dwarfs (in the galactic plane to optimize the number of reference stars), we are searching a region of exoplanet parameter space that has yet not been possible to cover with RV surveys. The program was granted a large allocation on the Palomar Hale 200" telescope in 2008 (data reduction is ongoing), and time has also been allocated to continue the survey in 2009.

CAMERA: Low-cost Robotic Laser Guide Star AO (Project Scientist)

We are developing a new compact LGS AO system for 2m-class telescopes that promises to reduce the cost of such systems by an order of magnitude (Britton et al. 2008). Using newly-developed off-the-shelf components, such as MEMS deformable mirrors and ruggedized 10W UV lasers, we are designing and building a robotic LGS AO system for the Palomar 60" telescope. With a high-time-efficiency AO system on a dedicated telescope we will be able to perform the first surveys of thousands of targets at high-angular-resolution, a huge step up from programs feasible with the current generation of AO and space observatories. I designed and built the optics for our testbed system as well as developed the detailed science cases -- which include the largest-ever search for close substellar companions to nearby stars.

Visible Light Adaptive Optics (PI)

am PI for LAMP (LuckyCam, adaptive optics, aperture masking and polarimetry at Palomar), an experimental instrument which used Lucky Imaging (Law et al. 2006) frame selection behind the Palomar adaptive optics system to achieve the first diffraction-limited visible light direct imaging on a large telescope. The system worked very well, achieving 2X HST resolution at 700nm, and has led to several papers (eg. Law et al. 2008b, Law et al. 2008c, Gladysz et al. 2008). Caltech has now incorporated a similar instrument into its plans for the next-generation Palomar adaptive optics system. The project was named one of Time Magazine's Best Inventions of 2007.

REFEREED PUBLICATIONS

- The Palomar Transient Factory: Project Overview
N.M. Law, R. Quimby, S. Kulkarni, et al. 2009 *PASP* (near complete)
- The Palomar Transient Factory: Science Planning
A. Rau, S. Kulkarni, N.M. Law, et al. 2008 *PASP* (submitted)
- Getting Lucky with Adaptive Optics: Fast Image Selection in the Visible with a Large Telescope
N.M. Law, C.D. Mackay, R.G. Dekany, M. Ireland, J.P. Lloyd, A.M. Moore,
J.G. Robertson, P. Tuthill, H. C. Woodruff 2008 *ApJ* (in press)
- Taking the Measure of the Universe: Precision Astrometry with SIM PlanetQuest
S.C. Unwin, et al. 2008 *PASP* 120...38U
- The LuckyCam Survey for Very Low Mass Binaries II: 13 new M4.5-M6.0 Binaries
N.M. Law, S.T. Hodgkin, C.D. Mackay 2008 *MNRAS* 384 150L
- The Orbit of the Visual Binary ADS 8630 (Gamma Vir)
M. Scardia, R.W. Argyle, J.L. Prieur, L. Pansecchi, S. Basso, N.M. Law,
C.D. Mackay 2007 *Ast. Nachr.* 328.146
- Lucky Imaging: High Angular Resolution Imaging in the Visible from the Ground
N.M. Law, C.D. Mackay, J.E. Baldwin 2006 *A&A* 446, 739-745
- Discovery of five very low mass close binaries, resolved in the visible with Lucky Imaging.
N.M. Law, S.T. Hodgkin, C.D. Mackay 2005 *MNRAS* 368 1917L
- A Search for X-Ray Flashes with XMM-Newton
N.M. Law, R. Rutledge, S.R. Kulkarni. 2004 *MNRAS* 350 1079

REFEREED SPIE PAPERS / PROCEEDINGS

- Getting lucky with adaptive optics: diffraction-limited resolution in the visible with current AO systems on large and small telescopes
N.M. Law, R.G. Dekany, C.D. Mackay, et al. 2008 *SPIE* 7015
- Astrometric detection of exo-Earths in the presence of stellar noise
J. Catanzarite, N.M. Law, M. Shao 2008 *SPIE* 7013
- Lucky imaging and speckle discrimination for the detection of faint companions with AO
S. Gladysz, J. Christou, N.M. Law, et al. 2008 *SPIE* 7015
- Diffraction limited imaging in the visible from large ground-based telescopes: new methods for future instruments and telescopes
C.D. Mackay, N.M. Law, T.D. Stayley 2008 *SPIE* 7014

CAMERA: a compact, automated, laser adaptive optics system for small aperture telescopes
M. Britton, V. Velur, N.M. Law, et al. 2008 *SPIE* 7015

The 12K×8K CCD mosaic camera for the Palomar Transient Factory
G. Rahmer, R. Smith, V. Velur, et al. 2008 *SPIE* 7014

Finding Earth Clones with SIM
M. Shao, S. Unwin, C. Beichman, et al. 2007 *SPIE* 6693

High-resolution imaging in the visible from the ground without adaptive optics: new techniques and results
C. Mackay, J. Baldwin, N. Law, P. Warner 2004 *SPIE* 5492