REU

(Research Experience for Undergraduates)

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REU

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- **5-yr Proposal pending with NSF to establish REU Site at Caltech under the aegis of LIGO.**
  - REU Site centered on Campus, with extensions to Hanford and Livingston Sites.
  - Objective is to provide a "real-life," LIGO centered, research experience to a group of undergraduates from a broad spectrum of academic disciplines, recruited locally, nationally, and internationally.
  - Core funding from NSF REU-office, supplemented by small component of NSF LIGO funds and a major component of private funds.
  - LIGO/REU program will be part of Caltech UG education program, and benefit from existing infrastructure.
  - LIGO/REU Site
    - » Principal Investigator: R. Vogt
    - » LIGO Co-sponsors:
      - B. Barish (PI)
      - M. Coles (Head, Livingston Site)
      - A. Lazzarini (GL, Systems/Integration)
      - T. Prince (Physics)
      - F. Raab (Head, Hanford Site)
      - G. Sanders (PM)
      - K. Thorne (Theor. Astrophysics)
      - S. Whitcomb (GL, Detector)
    - » Research Supervisors: LIGO Science Group members

LIGO REU Opportunities

- **Areas:**
  - Detector R&D
    - » Detector development, modeling, and analysis
  - Operations, observing and data analysis
- **Disciplines:**
  - gravitational physics
  - astrophysics
  - metrology
  - optics
  - lasers
  - mechanical systems
  - controls
  - electronics
- **Facilities:**
  - 40m interferometer
  - Optics/mechanical systems laboratories
  - Campus Computing Organization
  - Observatory sites

LIGO REU Opportunities

- **Enrichment Programs:**
  - SULS: Summer Undergraduate LIGO Seminars
  - SURF (Summer Undergraduate Research Fellowship) Seminars
  - SURF Luncheon Visitor Program
  - SURF evening discussions on professional development
  - SURF round table discussions with leaders in academia, industry, and government
  - SURF communication seminars
  - Observatory site visit
  - Social programs

LIGO REU Structure

- **REU Site PI and co-sponsors**
- **Research Supervisors**
- **Undergraduate Students**
  - SURF Students (Summer Undergraduate Research Fellowship, a campus-wide program):
    - » 10-week intensive Summer research experience, pursuing individual, independent research projects
    - » Students develop research proposals with potential LIGO Research Supervisor
    - » Students selected by Campus committee
    - » Bi-weekly reports to Caltech SURF office; final report on research accomplished; public seminar on completed work
    - » Mentoring by LIGO Research Supervisors and REU Site PI
  - LIGUR Students (LIGO General Undergraduate Research, a LIGO specific program):
    - » Independent or collaborative research with senior scientists or engineers
    - » Students participate in communal activities with SURF students
    - » Research has intensive 13-week Summer component, and may continue on reduced basis throughout academic year
    - » Students selected by LIGO project

Research Experiences for Undergraduates (REU)
Summary Project Budget
Justification

Line	Description	*FY 1997 (Then Year $)*	*FY 1998 (Then Year $)*	*FY 1999 (Then Year $)*	*FY 2000 (Then Year $)*	*FY 2001 (Then Year $)*	*Total*
	Escalation	1.000	1.030	1.061	1.093	1.126	
F.1.	Stipends	59,050	60,822	62,646	64,526	66,461	313,504
F.2.	Travel	2,500	10,300	10,609	10,927	11,255	45,591
F.3.	Subsistence						
F.4.	Other	5,000	5,150	5,305	5,464	5,628	26,546
F.	*Total Participant Costs*	66,550	76,272	78,560	80,916	83,344	385,642
I.	*Administrative Allowance (in lieu of indirect costs)*	14,763	15,205	15,662	16,131	16,615	78,376
J.	**Total Direct and Indirect**	81,313	91,477	94,221	97,048	99,959	464,018

Escalation: Three percent per year (All values below are FY 1997 dollars)

Line F.1. Participant Support Costs (Stipends - paid as hourly wage)

5	Summer students, 40 hours per week for 13 weeks, @ $11/hour =	$28,600
5	Summer students (partially paid by SURF), 40 hrs, 10 wks, @ $4.50/hr =	$ 9,000
5	Academic Year students, 10 hours per week for 39 weeks, @ $11/hour =	$21,450

Line F.2. Participant Support Costs (Travel)

FY 1997 - FY 2001 - travel support for non-Caltech students (5) @ $500/student =	$ 2,500
FY 1998 - FY 2001 - field trip (site visit) for ten students @ $750/student =	$ 7,500

Line F.4. Participant Support Costs (Other)

Miscellaneous Participant Support Costs (fees, materials, etc.) =	$ 5,000

Summer '96 REU Pilot Program: Funding

- **14 UG students**
  - 10 SURF
  - 4 LIGUR
  - (10 physics, 2 computer sciences, 2 electrical engineering)
- **Core funding from NSF REU Supplement Grant ($48,000)**
  - 4 students: REU (100%)
  - 7 students: REU/SURF (50%/50%)
  - 3 students: LIGO (100%)
- **SURF stipend ('96): $3,600/10 wks**
- **LIGUR rates ('96): $7.20/hr - $13.75/hr**

Summer '96 REU Pilot Program: SULS

- **SULS: Summer Undergraduate LIGO Seminars**

DATE	SPEAKER	TOPIC
June 20	Prof. Barish	LIGO
June 28	Prof. Braginsky	Friction
July 12	Prof. Braginsky	W.C.Heisenberg...
July 19	Prof. Braginsky	A Bunch of Unknown Enemies
July 26	Prof. Thorne	Sources of Gravitational Waves for LIGO
August 2	Dr. Sievers	Seismic Isolation
August 9	Dr. Whitcomb	LIGO Interferometers
August 16	Dr. Kawamura	Noise in Ambush
August 23	Dr. Sanders	Building LIGO, a Big Science Project

Summer '96 REU Pilot Program: Research

LIGO/SU96/1: Lock Acquisition of an Optical-Lever Based Alignment System in the LIGO 40m -Interferometer.

(J. Hess, SURF, Leicester [UK] and Siegen [Germany], RS: Dr. R. Spero): Test masses in the 40m interferometer are damped by servo systems using optical levers. Currently, the system tolerates only limited motion of the laser beam within the aperture of a quadrant photodiode. When the disturbance is out of range, the system fails, and the servos are disabled until the motion damps naturally.

The SURF project is to develop a dynamic response system, including computer controlled forces, that guarantee damping of large amplitude swings within a few seconds.

LIGO/SU96/2: Automatic Compensation of Drift for Optical Alignment Into a Fixed Mirror Fabry-Perot Cavity.

(A. Chen, SURF, Caltech, RS: Dr. R. Spero): The alignment of the laser beam into the 40 meter interferometer mode cleaner drifts on the time scale of hours. Currently, manual realignment is required periodically.

The SURF project is to develop a computer controlled automatic alignment using piezo controller mirrors and power optimization.

LIGO/SU96/3: Servocontrol of Optical Lever Launch Beam Drift.

(A. Collins, LIGUR, Caltech, RS: Dr. R. Spero).

• Test masses and beam splitter in the 40 meter interferometer are kept aligned by a global laser (launch) beam which has inherent thermal drifts.

The LIGUR project is the design and construction of a control system that stabilizes the beam with piezo controlled mirrors.

• Design and install a laser system that monitors the long termdrift of 40 meter interferometer seismicisolation stacks.

Summer '96 REU Pilot Program: Research

LIGO/SU96/4: Performance Analysis of the 40 Meter Interferometer From Time-Domain Data Analysis.

(Y. Wang, LIGUR, Caltech, RS: Dr. M. Coles): Analyze 40 meter interferometer data and their spectral features from time domain analysis of the interferometer and correlation with physics phenomena.

LIGO/SU96/5: Guided Lock Acquisition Sequences in Multiple Interferometer Cavities.

(W. Yin, SURF, Cambridge [UK], RS: Dr. L. Sievers): The LIGO interferometer will have 6 suspended mirrors which make up 4 optical cavities, with laser light resonating in each.

The SURF project is to develop, from existing computer models, the formulation of a best strategy for locking of multiple cavities in the presence of seismic excitation.

LIGO/SU96/6: Materials Study of Wire Suspensions for LIGO Test Masses.

(D. J.Dawid, SURF, Cambridge [UK], RS: Dr. S. Kawamura): The SURF project is to study ways of improving the LIGO test mass suspension system through use of different materials and damping methods for the suspension wires in order to minimize thermal noise (enhance Q) in the LIGO gravitational-wave band.

LIGO/SU96/7: Numerical Thermoelastic Analysis of Complicating Factors in Optics Used in Laser Interferometers for Detection of Gravitational Waves.

(D. Djambazov, SURF, Caltech, RS: D. Coyne): Thermo-elastic deformation, thermal lensing, and thermoelastic birefrigence due to absorption of laser light in the coatings of optical substrata impair the performance of the LIGO interferometers.

The SURF project pursues a better understanding of these thermal noise effects within realistic geometries, including non-normal incidence of light, large wedge angles, non-axisymmetric laser beams, and inhomogeneous absorption.

Summer '96 REU Pilot Program: Research

LIGO/SU96/8: Locating Correlated Noise Sources in the 40 Meter Interferometer.

(D. Relyea, SURF, Caltech, RS: Dr. A. Kuhnert): Analysis of multi-channel data from the 40 meter interferometer (slow monitor) to discover correlations with "technical" noise sources, allowing their ultimate removal.

LIGO/SU96/9: Critical Parameter Specifications for Shaped Optics in GW Interferometers.

(A. Jones, LIGUR, Caltech, RS: Dr. W. Kells): An FFT code simulates wave propagation through the LIGO interferometer. It is being used to study the effects on detector sensitivity of deviations from ideally shaped optics, i.e. wavefront aberrations. The results are being used in mirror specifications and optics development.

LIGO/SU96/10: Characterization of LIGO Optics.

(T. Yarnall, LIGUR, Caltech, RS: Dr. S. Whitcomb): A testing facility to measure scattering and absorption of laser light by LIGO optics has been built and is being used to characterize LIGO Pathfinder optics before final specifications.

LIGO/SU96/11: Qualification of Materials for LIGO Vacuum System.

(T. Lam, SURF, Caltech, RS: Dr. A. Kuhnert): LIGO mirror optical coatings are strongly affected by contaminants, which under laser light lead to excessive absorption and consequent thermal figure distortions. An acceptance testing setup for all volatile producing material, using LIGO style mirrors and cavity ringdown measurements of materials exposed over long times to laser light in test cavities is being developed for 1.06 laser light.

Summer '96 REU Pilot Program: Research

LIGO/SU96/12: Design of Recycling Mirror Control Servo Electronics.

(P. Storaasli, SURF, Caltech, RS: J. Heefner): In order to keep the recycling-beam splitter cavity of suspended mirrors in lock, a sophisticated servo control electronics is required. Using computer design tools (normally not available in Caltech classes!), the SURF project will design, prototype, and test the servo control circuit.

LIGO/SU96/13: Conversion of the LIGO FFT Program for Parallel Supercomputers.

(A. Laucius, SURF, Caltech, RS: Dr. K. Blackburn): The LIGO project uses an FFT code to simulate wave propagation through the interferometer and to evaluate the effect of perturbations on performance.

The current program is quite slow and thus prevents the full exploration of all interesting parameters. The SURF project is to convert this program for parallel supercomputers, to maximally optimize it for speed and memory usage.

LIGO/SU96/14: LIGO FFT Graphical Front End.

(A. Brichford, SURF, Caltech, RS: Dr. H. Yamamoto): The current version of the LIGO FFT program (see above) for simulation of wave propagation through the interferometer has a very poor user interface, and is therefore usable only by a limited number of "experts."

The goal of the SURF project is to design a front end that makes it possible for more users to exploit the FFT program easily. Success will be measured by the ability of the user to concentrate on their work instead of the execution of the FFT program.