Astrophysical **S**ource **I**dentification and **S**ignature (**ASIS**) Report

LSC General Meeting, August 2000

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ASIS Overview

- Since last LSC meeting, ASIS has met three times (teleconference). Regularly-scheduled monthly meetings will start this Fall.
- Mailing list:110 members of whom ~25 actively doing ASIS coordinated-work

  Chair: Bruce Allen

  Webmaster: Patrick Brady

  Meeting Organizer: Alan Wiseman

  Secretary: Alberto Vecchio

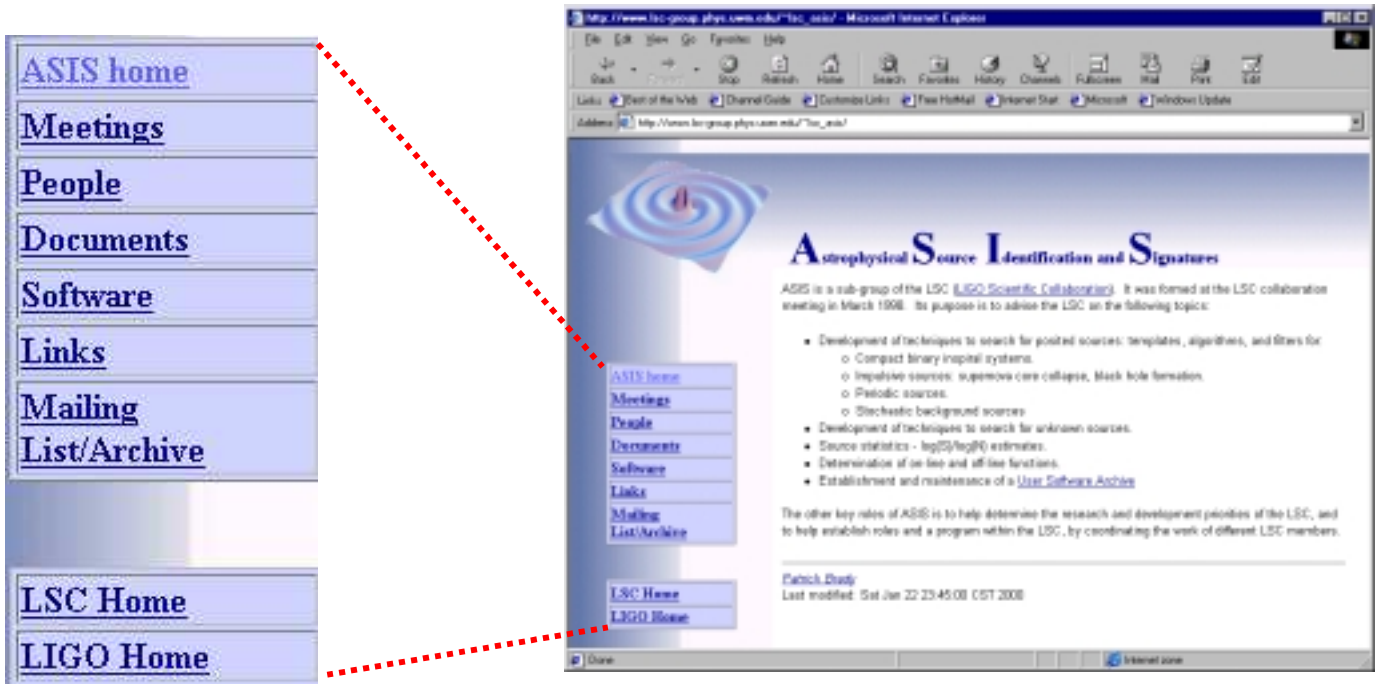
  LIGO Laboratory Liaison: Barry Barish

ASIS Web Site: www.lsc-group.phys.uwm.edu/~lsc_asis/

Documents, software, & links

Meetings announcements, agendas & minutes

Mailing list & archives



LIGO-XXXX

Organization of ASIS Work

- Priorities set in “LSC Data Analysis White Paper”.
- In August 1999, finalized lead groups for different software development/coding tasks.
  Note: several “high-priority” tasks still unassigned
- Analysis codes collected in public LAL Library
  - » current release 0.4
  - » code and documentation available for public examination
  - » auto-documentation system
  - » installs and runs properly on many platforms (intel/alpha linux, solaris, irix, digital unix, etc.)
  - » easy interface to the LIGO Data Analysis System

Organization of ASIS Work

- Current Lead groups for coding/development work:
  - **Albert Einstein Institute** (MPG - Potsdam): hierarchical pulsar search
  - **Caltech**: known pulsar search
  - **Cardiff**: (1) binary inspiral search - template generation & placement
    (2) “blind” line-tracking time-frequency search
  - **Cornell**: (1) transient source search with power statistic
    (2) robust stochastic background search
  - **U. Michigan**: amplitude-modulation discriminator (antenna pattern)
  - **U. Texas - Brownsville**: stochastic background search
  - **U. Wisconsin - Milwaukee**: (1) binary inspiral search - hierarchical filtering code (2) hierarchical stack-slide pulsar search
- Other groups actively participating in ASIS include: CFA, CIT-TAPIR, LLO, Stanford, TAMA, UFG

Pulsar Search: Albert Einstein Institute (Potsdam)

- Entire AEI gravitational-wave group
- General-purpose code. Expected sensitivity:
  - » Infinite CPU: detector-limited sensitivity $h \sim 10^{-25} \cos(\phi(t))$
  - » 100 Gflops: 4-month equally-sensitive search of Galaxy with no spindown (pulsars > 10^7 years old) in frequency range 500-1000 Hz
- Area search method: three-step hierarchical
  1. Start with database of short (~1 hour-long) FFTs. Combine (with demodulation) 24 of these to make ~1-day long demodulated FFT for large sky-position/spindown “patch”. Identify frequency-space “peaks”.
  2. Use Hough transform to look for pattern of peaks consistent with small sky-position/spindown “patch”.
  3. If threshold exceeded, follow up with coherent demodulation.

Pulsar Search: Albert Einstein Institute (Potsdam)

- Current status:
  - » Source database code completed for several source types, from NASA ADC, Princeton Pulsar Group, and Parkes multi-beam survey catalogs.
  - » Earth GPS time to solar-system barycenter time conversion code completed (uses JPL ephemeris data to replace TEMPO package!).
  - » Demodulation code completed and tested (used in stages 1 & 3).
  - » Coarse parameter space gridding code now undergoing testing. Fine gridding code now underway
  - » Hough transform code (used in stage 2) coding underway, currently several implementations. Working with VIRGO-Rome group.
- Open problems:
  - » How to take full advantage of correlations in source-parameter space
  - » Finding a very efficient implementation of the Hough transform

Pulsar Search: Caltech

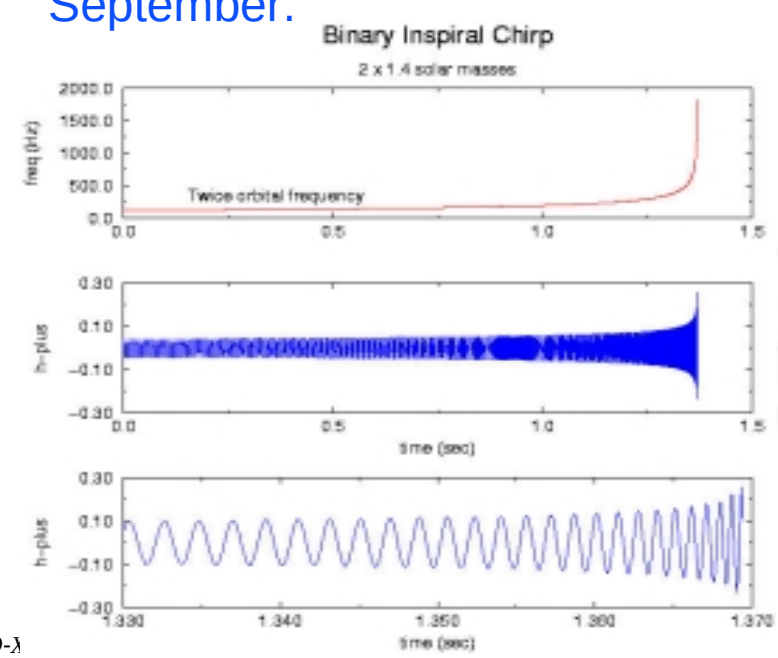
- Stuart Anderson
- Search for GW emission from known (radio) pulsars.
- Will obtain detector-limited sensitivity $h \sim 10^{-25} \cos(\phi(t))$ using insignificant computational resources.
- Method: for each known pulsar, fold (add together) time-series GW data using correct period pre-determined from radio data.

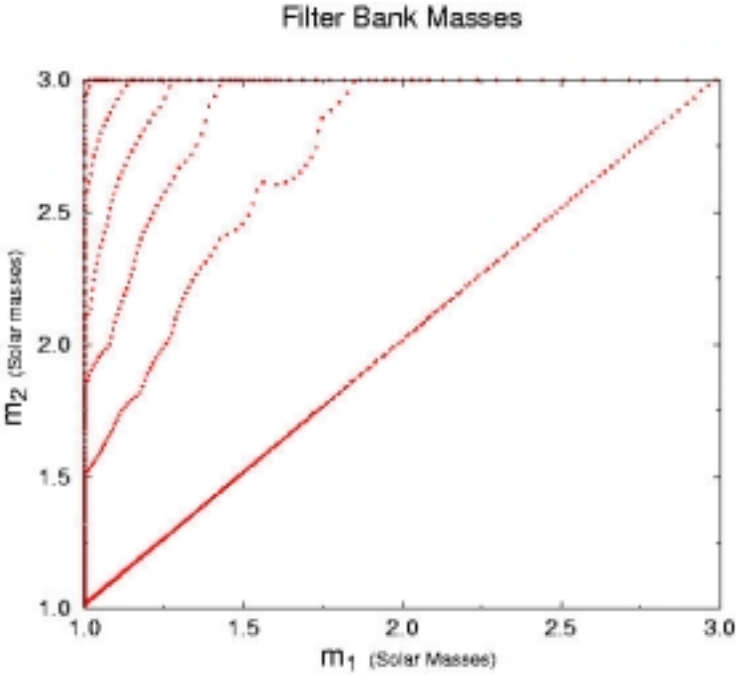
Binary Inspiral Search: Cardiff

- D. Churches and B.S. Sathyaprakash
- “Half” of binary inspiral search code (filtering “half” from UWM)
- Inspiral waveform template generation and parameter-space gridding.
- Produce accurate or “best” waveforms:
  - » 2.5 post-Newtonian order
  - » systems from 0.1 to 30 solar masses
  - » Taylor and Pade approximation methods
  - » time-domain & stationary-phase in frequency-domain.

Binary Inspiral Search: Cardiff

- Current status
  - » time and frequency domain Taylor & Pade approximant code in LAL for spinless zero-eccentricity systems.
  - » Coding for template placement now underway - should be completed by September.





Line-Tracking Time-Frequency Search: Cardiff

- R. Balasubramanian, W. Anderson, E. Chassande-Mottin
- Method looks for “curves” in time-frequency diagram
- Useful technique for unmodeled sources, such as high-mass binary systems
- Current status: time-frequency transform code complete & in LAL:
  - » Wigner-Ville
  - » Windowed FFT
  - » Reassigned Spectrogram
- Steger’s line-tracking algorithm complete
- Currently being tested on LIGO engineering data

Power Statistic: Cornell

- E. Flanagan, P. Brady, J. Creighton
- Method looks for “rectangles” in time-frequency diagram with excess energy
- Useful technique for unmodeled sources
- Code complete & in LAL
- Paper documenting method “in preparation”

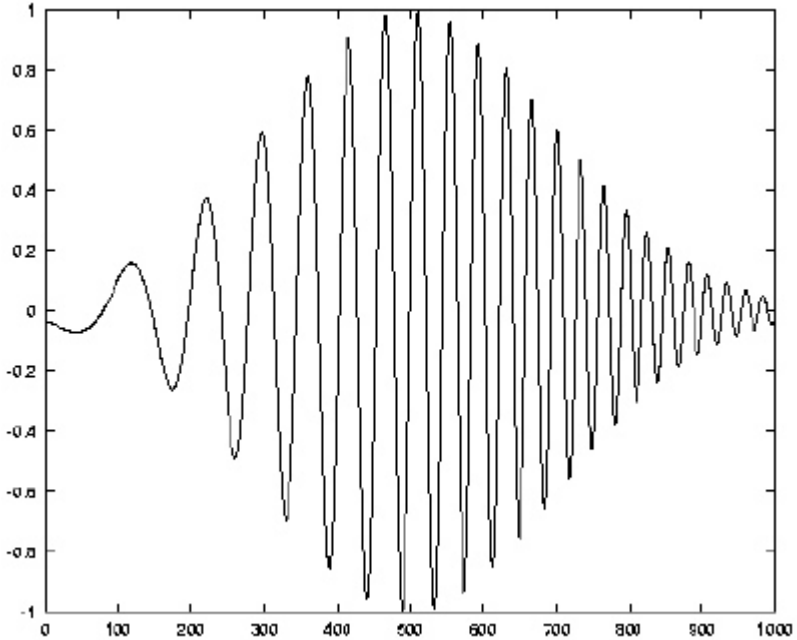


FIG. 1. Waveform in the time domain.

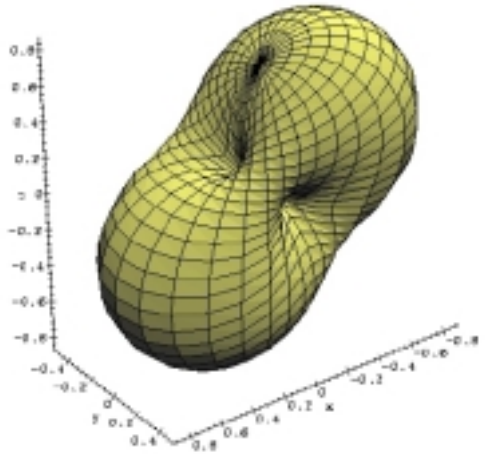
Robust Stochastic Background Detection: Cornell

- E. Flanagan, S. Drasco
- Method to search for stochastic background by correlating two or more detectors
- Generalization of the “traditional” two-detector correlation method, which gives optimal treatment of some types of non-Gaussian detector noise, in weak signal limit
- Paper documenting robust method is completed.
- Code being written in collaboration with UTB group and others.

Amplitude Modulation Discriminator: U. of Michigan

- D. Chin, K. Riles
- Tools to see if the amplitude of a posited source (for example a pulsar) exhibits an amplitude modulation consistent with it's inferred position.
- First version is completed, and in LAL library.
- Testing revealed several errors in literature.

Typical antenna pattern (average sensitivity to both source polarizations)



Stochastic Background Detection: U. Texas - Brownsville

- J. Romano, M. Diaz, E. Flanagan, A. Vecchio, C. Ungarelli
- Method to search for stochastic background by correlating two or more detectors
- Tool-kit for multi-detector correlation
- Filter bank will search for $\Omega(f)$ of "broken power law" form
- Should enable detector-limited sensitivity of $\Omega(f\sim100\ \text{Hz})\sim10^{-6}$ in four months of integration with the two LIGO detectors.
- Some code in LAL, more coming soon.

Hierarchical Binary Inspiral Search: U. Wisconsin - Milwaukee

- B. Allen, P. Brady, D. Brown, J. Creighton, A. Wiseman
- The “filtering half” of the binary inspiral search code (Cardiff doing templates, template placement)
- Implements general N-level hierarchical search through arbitrary set of templates
  - » Family of post-Newtonian binary inspiral waveforms
  - » Black hole horizon-formation ringdown
- Code now complete.
  - » Being used as example for building/testing LIGO Data Analysis System “Wrapper API” interface
  - » Undergoing first stage of testing (simulated Gaussian noise)

Hierarchical Stack-Slide Pulsar Search: U. Wisconsin - Milwaukee

- P. Brady, T. Creighton
- General-purpose code for area or targeted searches. Uses a two-step hierarchy:
  - » On coarse grid:
    - – Demodulate short time-series for given source parameters (sky position & spindown)
    - – Combine resulting FFTs by sliding (depending on source parameters) and adding power.
  - » For grid points exceeding threshold, repeat on (selected) fine grid
- Expected sensitivity: similar to Hough-transform search (details in papers by Brady & T. Creighton).

Hierarchical Stack-Slide Pulsar Search: U. Wisconsin - Milwaukee

- Current status:
  - » low-pass filtering code completed
  - » time series resampling completed
  - » power spectrum sliding completed
  - » power spectrum summing completed
  - » Currently at work on fine template bank