University of Minnesota Twin Cities Application to Join the LSC

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Proposal Summary

- I will join the Physics Department at UMN Twin Cities in the Fall 2007, after 3 years at LIGO-CIT.
- I propose to form a new LSC group:
  - » ~1 postdoc
  - » ~2 graduate students (and ~2 undergraduates)
- Research program:
  - » Stochastic searches
  - » Detector diagnostics and characterization
  - » Beyond AdvLIGO technology: gravity gradient noise
    - – Underground interferometry
- Continue present roles:
  - » Co-chair of the Stochastic Working Group
  - » Member of the Data Analysis Council
  - » Co-chair of the Hardware Injections Subgroup
  - » Member of the Calibration Review Committee

UMN Twin Cities

- Leading campus of the UMN system.

Students	Undergraduate	Graduate
Total	28,957	13,564
Institute of Technology	4063	2292

- Academics:
  - » 3356 Faculty
  - » 370 Fields of Study
  - » Degrees (2005):
    - – Bachelor: 6088; Masters: 2798; PhD: 678
  - » Research Support: > $561,000,000
  - » Library housed in 14 buildings
    - – 6.2 million print volumes
    - – nearly 37,000 serial subscriptions

UMN School of Physics and Astronomy

- **Faculty and Students**
  - » **Faculty: 36 (Physics) + 9 (Astronomy)**
  - » **Undergraduate: 90 (Physics) + 30 (Astronomy)**
  - » **Graduate: 134 (Physics) + 23 (Astronomy)**
- Research
  - » Experimental Astrophysics/Cosmology:
    - – CMB, Dark Matter, Formation and Evolution of structure (stars, planetary systems, galaxy clusters etc)
  - » Cosmology theory:
    - – Inflation, BBN, particle Dark Matter, neutrino astrophysics
  - » Strong HEP experiment and theory groups (CMS, MINOS…)
  - » Condensed matter, nuclear physics, biophysics
- **Operating Soudan Underground Laboratory (Soudan, MN).**
- Good machine shop, LHe recovery plant etc.
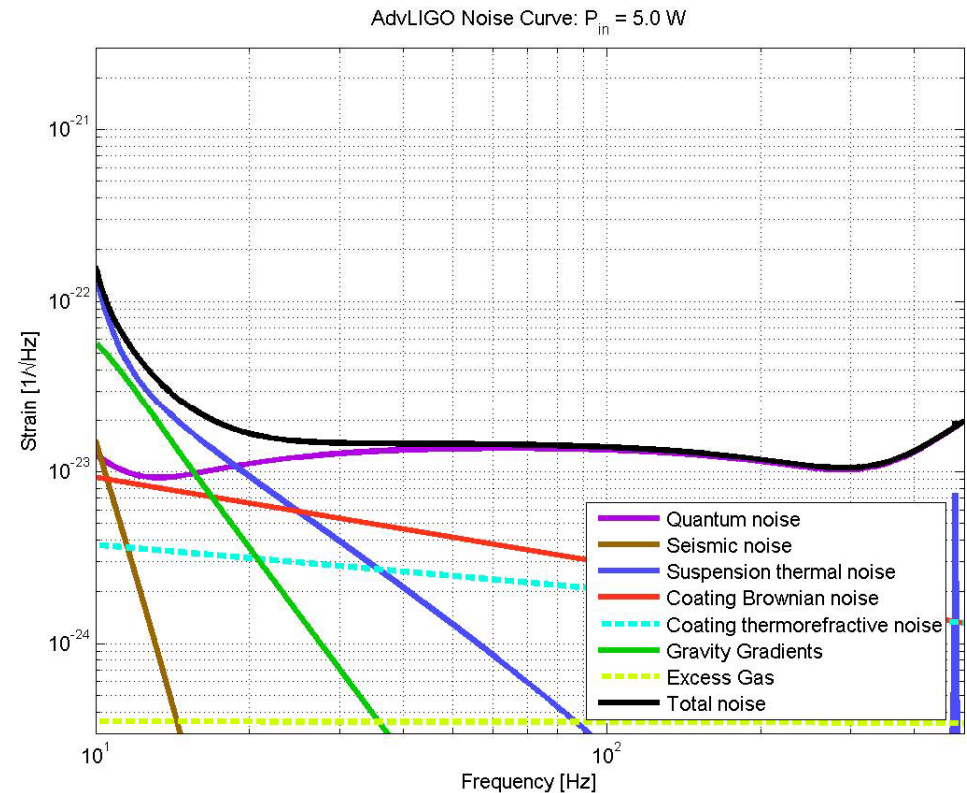
Stochastic Searches

- Continue the role of the Group Co-chair.
- Continue involvement in different analyses:
    - » Isotropic search using H1-H2 pair
        - – Interesting collaboration with Nelson Christensen at Carleton College, whose group calculates IFO-PEM coherences.
    - » Directional searches
        - – Group currently developing spherical harmonic decomposition technique.
        - – Study performance of different algorithms (isotropic, radiometer, spherical harmonics) for different sources (astrophysical, cosmological).
    - » Implications of the search results for various models
        - – Include astrophysical models (collaboration with Tania Regimbau) and cosmological models (previous collaborations with Xavi Siemens and Alessandra Buonanno)
- The stochastic pipeline upgrade will produce time-frequency map of the LHO-LLO cross-correlation.
    - » Parse this data to look for transients on the time-scale of minutes/hours.
- Possibly develop a computer cluster to be shared with the HEP group.
    - » Possible support from the UMN Supercomputing Institute.

Diagnostics and Characterization

- Development of diagnostic tools that would help commissioning efforts.
  - » Build on existing tools, such as DTT.
  - » Matlab based:
    - – Good graphics capabilities.
    - – A number of useful toolboxes (optimization, simulink etc).
    - – Relatively easy to code: Allow others to develop their tools.
  - » Study coupling mechanisms of different noise sources:
    - – e.g. multiple coupling mechanisms, linear vs bilinear, upconversion
    - – Complementary to the NoiseBudget
  - » Good way for UMN students to get involved in the activities at the sites.
- Hardware Injections
  - » Continue as a co-chair of the Hardware Injections Subgroup
  - » Expand the selection of waveforms for future runs
  - » Introduce a more automated "blind" injection mechanism
- Long-term coherence calculations
  - » LHO-LLO and H1-H2

Gravity Gradient Noise

- Gravity gradient noise may become important for AdvLIGO (and beyond).
  - » At low frequencies and with low laser power.
- Try to develop a technique to suppress it.
- One possibility: install an array of accelerometers throughout the site and feed back to the mirrors.
  - » Or, possibly do an offline subtraction.
- Will require simulations at first.
  - » G. Cella already performed some such studies, indicating 10-100x suppression is possible.
- Depending on simulation results, possibly develop some techniques in the lab on UMN campus.
- Collaborate with Giancarlo Cella, Szabi Marka, and others.

AdvLIGO Noise Curve: P_{in} = 5.0 W

Strain [1/√Hz] vs Frequency [Hz]

- Quantum noise
- Seismic noise
- Suspension thermal noise
- Coating Brownian noise
- Coating thermorefractive noise
- Gravity Gradients
- Excess Gas
- Total noise

Long Term: Underground Interferometry

- Underground interferometer may be sensitive to GW at 1Hz or below.
  - » Seismic (and gravity gradient) noise is suppressed.
- Will require new solutions for thermal noise etc.
- UMN operates the Soudan Underground Lab, where some of the initial tests could be made.
- Also, relatively close to the Homestake mine, SD, which was recently chosen as the DUSEL site (Deep Underground Science and Engineering Laboratory).

Conclusions

- I enjoyed being a part of the LSC over the past three years.
- I look forward to future collaborations with LIGO and LSC members as I move onto a faculty position at UMN Twin Cities.
- I hope to build a well-rounded group at UMN, with significant involvement in activities at the LIGO sites, in data analysis efforts, and in R&D efforts for beyond AdvLIGO.
- UMN Twin Cities and its Physics Department provide a very vibrant and scientifically stimulating environment!
- Twin Cities: great location for a collaboration meeting!