

Report of the External Review Committee **Department of Astronomy and McDonald Observatory**

In response to a request from Dr. Mary Ann Rankin, Dean of the College of Natural Sciences at the University of Texas at Austin, the External Committee met in Austin between March 29 and April 2, 2009 to review the Department of Astronomy and the McDonald Observatory of the University of Texas at Austin. The committee consisted of Dr. Wendy Freedman, of the Observatories of the Carnegie Institution of Washington, Professor Jonathan Lunine, of the University of Arizona, Professor Anneila Sargent of the California Institute of Technology, and Professor Michael Skrutskie of the University of Virginia.

A considerable body of information regarding the Department and the Observatory was made available to the committee well ahead of the Austin visit. This was supplemented by presentations from, and interactions with, members of the department in Austin on March 30 and 31. Faculty, research scientists, and postdoctoral fellows, as well as graduate and undergraduate students participated. A subset of the committee (Lunine and Skrutskie) visited McDonald Observatory on March 31/April 1. A phone link enabled the other members (Freedman and Sargent) to hear the on-site presentations from Observatory personnel on April 1. A meeting of the full committee with Department Chair, Neal Evans, and McDonald Director, David Lambert, at the end of the day on April 1, provided an opportunity to discuss any remaining issues.

The committee was charged to address a number of questions, including:

1. the quality of the faculty and research programs now underway
2. the quality and effectiveness of the undergraduate and graduate programs
3. the adequacy of resources for teaching and research in the near term
4. the potential for future research and programmatic development
5. the associated implications for ongoing faculty recruitment
6. the connections between the Department/Observatory and the local communities

We found it most effective to address other issues that are explicitly raised in the charge in our responses to these questions. As appropriate, we also discuss additional issues that came to our attention during our deliberations.

1. The Quality of the Faculty and Current Research Programs

1.1 Faculty

The UT astronomy faculty is engaged in a wide range of research activity covering solar system studies, exoplanet detection, star formation, stellar astronomy, instrumentation, extragalactic astronomy and cosmology. In total, there are 20 faculty members, and a comparable number of research staff. At the time of the last National Research Council (NRC) review of Astronomy Programs in 1995, the Department ranked 10th nationally, placing fourth behind UC Berkeley, UC Santa Cruz and the University of Arizona among state institutions. That ranking derived both from the breadth and talent of the Department and from its access to the resources at McDonald Observatory. Since then, the Department

has strengthened its extragalactic astronomy and theory groups, and will soon add a talented hire in the area of planetary systems science; the promise of the Hobby-Eberly Telescope (HET) is beginning to be fully realized, and there has been commendable progress in increasing the numbers of women faculty. Over the next decade, the Department seeks to become the top state university for astronomy in the country, and to rank amongst the top several elite institutions overall. The Visiting Committee believes that the department has positioned itself well to pursue this ambition. This report highlights areas where the potential for success can best be pursued, through both the direct efforts of the Department and via the support of the Administration. We recognize that this kind of progress cannot be made without substantial financial commitment. However, even in the current difficult economic climate, the Department's success to date makes it easy to argue that focused investment is well warranted, if not essential, to exploit and foster near-term opportunities

Faculty hiring was presented to the committee as the biggest issue for the Department. In recent years, the hiring program has been remarkably successful. However, if this is not sustained, the faculty size and effectiveness will contract substantially over the next decade. In the current fiscal climate, well-chosen new faculty have become an even more precious commodity and the committee recommends that the Department formulate a detailed strategic hiring plan as soon as possible. With university cutbacks, it may prove challenging to grow the faculty to number 30 as outlined in the most recent strategic plan. It is therefore critical for the faculty to make a clear scientific and academic programmatic case for its personnel goals. It is the view of our Committee that a shrinking of this department would be a major blow to its momentum as the Hobby-Eberly Dark Energy Experiment (HETDEX) and Giant Magellan Telescope (GMT) era begins. It would also severely impede its aspirations to maintain world-class scientific programs that would ensure productive access to future facilities such as ALMA (Atacama Large Millimeter Telescope) and JWST (James Webb Space Telescope), while maintaining a broad teaching program. As the most recent Departmental hires have demonstrated, the introduction of carefully selected new individuals can catalyze productive collaborations between existing disciplines within the department and provide net gains substantially greater than the talent of the incoming researcher. We strongly recommend that future strategic planning for hires takes this perspective into account and make clear how each individual hire can lead to broad departmental gains.

As already noted, the recent hires into the department have been excellent. This makes retention an issue that must be monitored with some care, since a number of the current younger faculty are super stars. The situation is likely to become more challenging with time. The very democratic nature of decision-making on merit increases was of concern to the committee with respect to the ability of the Department to respond to aggressive outside competition. Many of the universities who will compete to attract faculty away from Texas also have far superior support services, such as child care. The University may wish to pay some attention to these issues.

1.2 Current Research Programs/Facilities

The research of the Texas Astronomy Department is substantially enhanced and uniquely enabled by the dedicated availability of the facilities at McDonald Observatory. These facilities include the HET, and the McDonald 0.9-m, 2.1-m, and 2.7-m telescopes. Most recently UT has joined the GMT as a Founding Partner, staking its claim in the arena of giant

aperture telescopes that will define the astronomy research frontier beyond the year 2020. The Observatory is also a longtime partner in the Caltech Submillimeter Observatory (CSO), enabling the Department to take a strong leadership position in the Spitzer space mission. Currently, the Department has two high-priority projects: 1) HETDEX and 2) GMT.

HETDEX: HETDEX is an extremely innovative and exciting project to measure the expansion history of the universe over the redshift range $1.9 < z < 3.5$, using the existing HET. Redshifts for 800,000 Lyman-alpha emitting objects will be measured to provide constraints on the effects of dark energy and a measurement of the Hubble parameter, H , and the angular diameter distance to a precision better than one percent at a redshift $z=2.4$. The experiment will use 140 nights over 3 years, most of the available dark time on the telescope. The constraints on cosmology will become even more interesting if the survey can be extended from the currently planned 400 square deg to 600 square deg in the future. The key for this group is to be able to deliver on a time-scale that is at least comparable, if not ahead of their competition, the Dark Energy Survey (DES), and the Baryon Oscillation Spectroscopic Survey (BOSS). This project represents an area where the University of Texas can take world leadership in addressing one of the most exciting, critical, not to mention mysterious, issues in modern science.

In addition to addressing the question of dark energy, the new VIRUS spectrograph will literally open a new field of emission-line survey science. A workshop held on Feb. 17- 18, 2009 highlighted the breadth and excitement of the additional science that will be enabled. For example, HETDEX will provide a measure of large-scale structure, the so-called cosmic web; it will provide an opportunity to search for the most metal poor stars in the Milky-Way Galaxy, and study its structure; and it will allow studies of the dark matter and star formation distributions in nearby galaxies. Pilot programs should be conducted in these other areas, and NSF or other funding sought for programs to make optimal use of HET beyond the dark energy experiment. The sheer volume of VIRUS/HETDEX data will be overwhelming and rich for scientific data mining. The Department can, like most distinguished departments, perform major community service by making the data publicly available after an appropriate proprietary period. We note that it is very likely that NSF funding for VIRUS will require this kind of commitment from the Department.

As reported to us, modifications to the HET appear to be on schedule and budget. The current critical challenge is to raise the additional \$12M to reach the total \$34M required for the project. Prospects for NSF stimulus funding look promising. However, if the NSF funds do not materialize, this group will need the strong continued support of the McDonald Board of Visitors, and the university administration. We strongly recommend that this group continue to be supported, and, importantly, supported in a timely manner so that HETDEX results can be obtained on a competitive timescale with other ongoing projects. This is clearly the highest current priority of the department, and is critical to its success in the near term.

GMT: With the support of the UT administration (Dean, Provost, President), the Department of Astronomy joined the GMT project in 2004. It has become a Founding partner, with the goal of a 10% share. Two UT members sit on the Board of Directors of the GMTO Corporation (Dean Mary Ann Rankin and Observatory Director David Lambert). Dan Jaffe is

chair of the Scientific Advisory Committee (SAC) for the GMT, and Phillips MacQueen has been a member of the technical, Project Science Working Group. UT has proposed two major first-light instruments for GMT: GMTNIRS, a high-resolution near-infrared spectrograph with a gain in some areas of 200 times that of existing 8-m spectrographs, (PI: Dan Jaffe) and QSpec, a high-resolution optical spectrograph (PI: Phillip MacQueen). The high-precision capability of QSpec will make it a premier instrument for finding Earth-like planets. Gary Hill and Karl Gebhardt are also involved in the proposal for GMACS, a multi-slit optical spectrograph (PI: Darren Depoy, Texas A&M University). At many levels, UT is an active partner in the design and development of the GMT project.

In terms of the Department's current research efforts, the committee strongly endorses their HETDEX and GMT goals. We urge the Department to articulate a long-term vision including not just the near-term (HETDEX) and far-term (GMT) plans, but in addition, to articulate clearly the scientific and instrumentation plans spanning the period between the completion of HETDEX and the commissioning of the GMT. The department must position itself to maintain a leadership role through the GMT era. The GMT has already played a role in helping to recruit younger faculty, and it will be critical for their retention. UT involvement in GMT instrumentation will have benefits beyond the GMT alone. Both HETDEX and GMT offer exciting opportunities for education and outreach, which should be exploited.

Articulation of a coherent vision is also essential to meet the challenging fund-raising goals for these initiatives. Enlisting the support of the University administration remains critical, and the McDonald Board of Visitors is a unique resource, which can be extremely helpful. Coordinating these efforts could yield a greater probability of success. To meet its goals for GMT partnership, UT will need to raise approximately \$2M per year for each of 3 years, ramping up to \$6M / year for construction. This will require a major development effort. The establishment and rapid development of the astronomy program at Texas A&M, which has many interests in common with the UT department, presents an opportunity that should be fully exploited to garner additional support, both directly and in joint approaches to donors and legislators. Almost every member of the state legislature is an alumnus or alumna of one or other of these Institutions.

2. The McDonald Observatory

The McDonald Observatory is a world-class facility at the forefront of astronomical research, education, and outreach. The University of Texas justifiably should be proud of this outpost of technological and scientific prowess in the far-flung mountains of the West Texas Desert – one which fosters considerable public interest and support. At the same time, no endeavor so challenging and so complex can be sustained without continued attention on the part of the University to problems of staffing and infrastructure. While we found great achievements, we also identified shortcomings in need of rectification sooner rather than later.

The Visitor's Center at McDonald is housed in a beautiful building generally suited for the mission of astronomical education. On the night of the Committee's visit (a Tuesday night) 200 visitors were in attendance at a star party hosted by the Visitor's Center. Such interest at such a remote site on a workday evening is astounding and illuminating of the reputation and

value of the facility. We found the classroom and associated educational programs held there to be particularly striking. The Center's educators encounter 2000 students a year in person; via videocon, the Center has been able to reach a population ten times larger throughout the state. The educational programs are tied to State of Texas standards and curricular guidelines, making them an important vehicle for increasing science achievement statewide. The talented staff there is enthusiastic and knowledgeable, and they themselves have identified what needs to be upgraded and changed in the Center to make it an even more effective tool for reaching the public. The exhibits are aging, with some outdated and others simply out of order. Chronic problems with the heliostat software system seem difficult to resolve. The Center has no bilingual educator, or even a Spanish speaking staff member, in spite of its geographic location in a heavily Hispanic part of the United States.

The issues outlined above can be addressed by a relatively modest increase in investment in the Center on the part of the University. Currently funding comes almost exclusively from sources outside of UT. Such investment today would make sense in view of the strong and very evident UT branding, and the important role the Center plays in science education.

The premier research facility at the observatory—the Hobby-Eberly Telescope (HET) has made great progress since the last review when the telescope was falling far short of its performance specifications. Thanks to an extensive series of modifications the HET is today doing the science which was originally envisioned for this behemoth. More needs to be done, but the scientific and technical staff, guided by the HET Board, have developed a prioritized set of technological improvements that will enhance the telescope's performance and enable it to conduct the HETDEX observations. The queuing system for observations is well-conceived, well-executed, and has led to a remarkably high percentage of time being used for scientific research—that is, the telescope is extremely efficient. The administration mode, in which the HET Board meets every 6 months, with telecons every two weeks, to guide the project, seems effective. Renewal of the HET agreement is upcoming in 2011; UT has a big stake in ensuring the success of any negotiated new agreement, given its investment in and identification with this world-class facility.

The hiring of a new operations manager who had extensive experience with the South African Large Telescope, the southern hemisphere equivalent of HET, is an excellent development that will maximize the likelihood of success of the ongoing technical modifications and upgrades to achieve HETDEX readiness. His own detailed analysis compellingly indicates that the current staff is barely adequate to maintain operations, and as parts of the telescope age and need replacement, will not be able to keep up. We observed a motivated, talented, but stressed staff. We also directly observed the impact of equipment that was down or broken and could not be replaced in a timely fashion. By the operations manager's convincing analysis, based upon direct experience at SALT, the HET, requires roughly 3 new staff members to enable the ongoing improvement of the facility beyond the current upgrade plans (whereas the current staffing level is likely marginally sufficient to keep up with ongoing maintenance and repair of the mature/aging facility). The technical staff of HET maintains a long list of much needed facility improvements. Only the first few items on this list can be accomplished with current staffing levels. Surprise failures will even threaten these improvement campaigns. It was not lost on the Committee that improved

consistent performance of the HET is essential to the timely completion of HETDEX – the key near-term objective of the Department. Direct investment in additional support staff is thus in the strategic best interest of the University. Since UT is the lead partner, and the telescope is strongly identified in the broader astronomical community with the UT program, it should take the lead in rectifying this shortcoming.

The McDonald Observatory's two-meter and smaller class telescopes also play key roles in astronomical research and public education. The ability of the public to use the 82-inch telescope on a regular basis is to be lauded as one of the only such programs in the world. However, the 2.1 meter is aging, and maintenance costs are expected to escalate in the near future. In order to justify a continuing significant investment in maintenance the Department should develop a long-term plan for this telescope that will return commensurate value. Given the large anticipated future cost, doing so must involve more than keeping the telescope open for routine scientific use. Such a plan could also include the identification of an external university as a partner in its operation. Both the 107-inch and particularly the 82-inch telescope represent superb platforms for a variety of small, student-conceived and built instruments that would continue the Department's very strong tradition of training in instrumentation design and construction – an identified critical need for the astronomical community in the near term.

The 107-inch telescope is the more modern of the two modest-sized telescopes and has benefited from substantial ongoing investment in instrumentation and image quality improvement over recent years. In particular, prototyping of the VIRUS project with the VIRUS-P spectrograph is in progress. This powerful instrument in its own right puts 250 fibers onto the sky in a close-packed configuration enabling remarkably efficient studies of extragalactic kinematics and star formation. Postdocs and graduate students are already drinking from this data firehose and producing first-rate scientific results from this instrument. These initial results promise a bright future for the 107-inch/VIRUS-P configuration, and the addition of this instrument along with the upgrades to the Coude spectrograph have literally rejuvenated this telescope and secured its future.

In general, maintenance is becoming more difficult on the mountain largely due to the age of the physical infrastructure. In addition, increasingly burdensome government regulations make once simple repairs both expensive and time consuming. Issues associated with living in a remote part of West Texas (for example the need for adequate health-insurance that recognizes the limited choice of health care providers in the region) create additional stress on the staff. We point out that these issues were called out in the last external review and have not been resolved. There is no effective way for the McDonald staff to interface with UT offices (despite an on-site HR person), and we detected a level of concern, even anxiety, that is unacceptable at such a complex and key facility. UT academic officers must step in and ensure that its employees—the heart and soul of this endeavor—can work and live in this remote site free of excessive hardships and concerns. The reinstatement of an Observatory Council could improve the situation by providing additional lines of communication between staff and the UT Astronomy Department, but other measures may also be required.

3. Quality and Effectiveness of the Undergraduate, Graduate, and Post-doctoral Programs

In addition to the information on academic programs provided by the Department, the committee received reviews of the undergraduate, graduate, and postdoctoral experience in the UT astronomy department from representatives of each of these bodies. We also met with representative undergraduates, graduate students and postdoctoral fellows in person.

3.1 The Undergraduate Program

Considerable attention has been given to maintaining and improving the overall quality of the undergraduate program for astronomy majors. The introduction of research as a key component of the program is notable, especially the efforts to enable students to spend time at McDonald Observatory. In addition, the committee notes with pleasure the success of the B.S. program that was recommended by the previous external review. This appears to provide excellent preparation for graduate school admission and has increased the number of departmental majors. The relatively straightforward path to a double major in astronomy and physics is a very attractive option that is likely to make UT graduates highly sought-after by the most prestigious graduate schools. The 2008 award of a Rhodes scholarship is probably just an early manifestation of the effectiveness of this program.

The committee is particularly impressed by the numbers of non-science students who take astronomy courses as part of their natural science requirements. We recognize the importance of making science approachable for a wide audience and see the service efforts of the department in this regards as highly commendable. While the numbers of astronomy majors *per se* may be relatively small, as many as 1400 students per semester are actually being taught astronomy – among the largest number at any university in the nation.

Likewise, the committee is enthusiastic about members of the Department stepping up to the challenge of enriching the experience of entering students with interdisciplinary signature courses. With its links to a wide variety of other disciplines, astronomy is an obvious choice for such courses and UT is fortunate to have astronomy faculty who are well-placed to develop appropriate topics and appear to be doing so successfully.

The Department's continuing efforts to improve the undergraduate program is laudable and the contributions of the new young faculty are undoubtedly broadening the scope of the signature courses as well as those available to astronomy majors. The future looks bright. The education offered by this department is first class. The only small concern of the committee is that this first class undergraduate experience should be available to a diverse body of students. From the data available, it appears that in terms of gender the non-astronomy major classes are well-balanced. In addition, Under-Represented Minorities form about 25% of these non-major classes. It is not clear that these encouraging numbers apply to astronomy majors. We have a sense that in the particular geographical location of UT a more proactive effort to recruit Under-Represented Minorities to astronomy – possibly as lead-in to other sciences - should be possible and effective.

3.2 The Graduate Program

With an average of 45 students over the last 8 years, the graduate program at UT is one of the largest, if not *the* largest, in the US. Moreover, a significant fraction of UT Astronomy PhDs are successful in finding rewarding positions in the field. The departmental emphasis on starting significant research early is much appreciated by the students, especially since the problems noted by the last external review committee regarding the required date by which a thesis advisor must be selected seem to have been resolved. The addition of graduate student representatives to appropriate departmental committees also appears to have alleviated many of their other concerns.

On the whole, the graduate program is well-constructed and implemented. However, the committee noted that the department's aspiration to be #5 in the nation in the foreseeable future brings with it an expectation that it will be producing the very best graduate students. Over the last decade, 10% of UT astronomy PhDs have won prize fellowships and/or gone on to prestigious faculty positions. To ensure that this percentage is not merely maintained but increases, we see a need for some modification of the graduate program. In particular, we regard it as critical that the program ensures that its PhD students acquire a broad general knowledge base in astronomy and astrophysics. We concur with faculty views that the current requirement that only 8 courses (taken over 2 semesters) be completed in fulfillment of the PhD cannot provide that base and suggest that the number of required courses be increased. We recognize that this may require some careful balancing against research and TA requirements but believe it to be important.

The committee was somewhat concerned that it seemed to be accepted that no one failed the qualifying exam; evidently unprepared students were simply allowed more time. If the standard of PhDs produced is going to be at the level of a #5 graduate school, some policies must be introduced that enable weaker candidates to be identified and given the opportunity to move on expeditiously.

An increase in the number of required fundamental courses might also go some way to alleviate the problem of limited graduate-level course offerings. Several possible solutions to the problem of limited graduate-level course offerings were offered by the department. None were as attractive or justifiable as adding additional course requirements. In fact, at present no course is absolutely required of the students; even the "Core" courses are effectively optional. The additional required courses might also allow a decrease in the overall number graduate seminars and fusion of some of those currently offered. Joint seminars would have the further advantage of breaking down boundaries between relatively narrow research areas and improving communication at all levels in the department. Finally, we note that in the past talented research scientists have taught courses to the benefit of students and to the program as a whole. We encourage the department to seek ways to revive this practice.

In terms of diversity, the gender balance seems reasonable. The fraction of women admitted has fallen somewhat in the last few years but this can still be attributed to small number statistics. As with many graduate programs across the country, the situation with regard to Under-Represented Minorities (URMs) remains a concern. The committee learned informally that in recent years 4 Hispanic students have earned PhDs. As with the

undergraduates, in the geographical location of UT it seems likely that even a small proactive effort could increase URM representation among the graduate student body.

3.3 Postdoctoral Fellows

Social and professional interaction – or, more precisely, the lack of it – is a major concern for the postdoctoral fellows. It came up in both their written submission and in our face-to-face meeting with them. An awareness of their particular difficulties has in fact percolated to the Department leadership and we learned in follow-up conversations that efforts are underway to improve both post-doc/post-doc and faculty/post-doc interactions. The committee endorses the Department's support of the recently-instituted post-doc lunches but suggests that they be encouraged to invite different faculty members to these from time to time. Naturally we expect that the faculty will make every effort to accept.

The committee also recognizes the frustration with current practice that has resulted in the post-docs instituting, with Department support, a mentoring committee that will track their progress and provide general “elder statesman” help and advice. We incline to the view that individual mentoring committees, tailored to the interests of each post-doc and appointed by the Department, would be most effective but understand that different departments must approach these internal issues in the ways they see best. The committee does recommend that every prize post-doc has a clearly identified mentor or sponsor.

We are not enthusiastic about isolating post-docs in a single wing of the building, as they suggest, believing that to be counterproductive in terms of increasing general interaction with the department. However, we agree with them that it is important to foster cross-disciplinary interaction and believe that the combined seminars discussed in §3.2 could go a long way to assist in this endeavor. Finally, we note that there was considerable confusion among the group we met regarding the details of UT policy on maternity/paternity leave. We suggest that details of this be included in the package prepared for entering post-docs.

4. The Potential for Future Research and Programmatic Development

UT has a distinguished history in star formation, planetary science, interstellar medium, and galaxy evolution studies and has produced numerous graduates who have gone on to distinguished careers across the nation. Over the next decade, it will be a major challenge to ensure that this research momentum is nurtured through careful distribution of resources. In this context, the committee was very pleased to learn of the establishment of the new Texas Cosmology Center. This center focuses on 4 timely and fundamental questions: 1) what is the nature of dark energy? 2) what is the nature of dark matter? 3) what is the origin of inflation? 4) how did the structure of the Universe emerge and evolve? These questions are tightly linked to the primary science for the highest priority facilities, HETDEX and the GMT, which will foster wide participation in the center. With an energetic and talented new director, and funding from the Administration, this new center has the potential to attract theorists from a broad range of areas overlapping the interests of the department. The collaboration with the Department of Physics and the involvement of Stephen Weinberg are exciting developments, and the synergy with Texas A&M and UT-Dallas provides excellent

opportunities to grow the involvement of talent (theoretical, experimental and observational) within the state.

We see the Texas Cosmology Center as important in and of itself but also as a proof of concept for other centers or research core groups that the Department of Astronomy could begin to organize to reflect its strategic directions. For example, with the hire of Sally Dodson-Robinson, efforts in the planetary sciences at UT will achieve a notable breadth and depth. Combined with the observational searches for exoplanets and studies of the composition of solar system bodies at the McDonald Observatory, the theoretical expertise in the department is now sufficient to merit examination of what a Texas Planetary Science Center might encompass. Notable here is the potential interaction with the College of Geosciences.

Already, the Department is a nationally recognized leader in star formation. This strength has been nurtured by a longtime partnership with the Caltech Submillimeter Observatory (CSO). We could imagine that a similar level of participation in the proposed successor to CSO, the Cornell Caltech Atacama Telescope (CCAT) might encourage a Center for Star and Planet formation that could include interstellar medium studies. As with early participation in the GMT, partnering in CCAT at this stage of its development can provide significant opportunities for influencing its instrumental and scientific development. The survey capabilities of CCAT and the possibilities for developing instrumentation that it provides would also enable the department to make optimum use of the international ALMA.

Finally, we note that the astronomy program at UT already involves a considerable number of connected programs and collaborations. These will only increase if centers such as those described above are successful. Constant vigilance is undoubtedly required to keep the lines of communication open between all the parties involved in these ventures. A number of our earlier recommendations treated communications issues at least indirectly. To these we would add a strong recommendation to revive the Observatory Council which, in the past, played a major role in maintaining informational ties within the department as well as between the Department and McDonald Observatory.

The Committee, recognizing the lengthy and complex nature of its recommendations, encourages you to contact us should any clarification be required.

Sincerely,

Anneila Sargent Wendy Freedman Jonathan Lunine Michael Skrutskie