process itself can be an important educational component, and mentors can discuss students' ideas with them and provide helpful guidance. Ultimately, of course, each application must represent the student's own best efforts. We offer some clarifications that may help students in P/A and their mentors.

NSF has two main selection criteria. The first criterion, "intellectual merit," includes the applicant's proposed plan of research, previous research experience, academic record, reference reports, and GRE test scores. The second criterion, "broader impact," includes three components: integration of research and education, potential contributions to diversity, and contributions to community. Although the most easily quantified measures such as grades and GRE scores remain important, these are clearly not the sole or determining factors. Panelists look for evidence of original thought, creativity, and depth of commitment to advancing science through research. A student with modest GRE scores who is highly distinguished in other ways has an excellent chance for a fellowship.

In describing proposed plans of research, the applicants' formulations of research questions and detailed descriptions of how they would address their questions reveal a lot about their thought processes. Candidates should focus on one or, at most, two research questions. A good plan includes background research to learn what projects are being pursued at the applicant's intended graduate institution. In describing their previous research experiences, applicants should state both what was accomplished and—perhaps more important—what they learned personally. Research experiences that extend beyond the applicant's own campus can indicate breadth of interest and motivation. It is of great importance that the applicant's writing be clear, concise, and free of grammatical and typographical errors.

The reference reports, both the letters and the rating sheet, are crucial. Panelists need specific information that gives a personal sense of each applicant. The most helpful reference letters provide insight into what makes the student exceptional, what the student has accomplished as a researcher, and how he or she thinks about physics. We urge faculty members to be specific, and to be consistent in the rating and the narration.

The "broader impact" criterion was the decisive factor for many applicants. But the questions related to that criterion were the most misunderstood. Panel members look for original, self-motivated contributions to the integration of research and education, such as the development of innovative teaching materials, significant volunteer work with science in local schools, or exceptional departmental service. "Potential contributions to diversity" refers to activities such as science advocacy that may help to increase the diversity of the US population that is entering science or is knowledgeable about it—for example, taking science to underrepresented population groups through work with schools or clubs. "Contributions to community" may include organizing or working with department-based initiatives, with science museums, or with students. Applicants and their mentors should address this point at the level of making a real difference in the lives of others.

The P/A panel and NSF value and encourage applicants who want to pursue a doctoral specialty in physics education research. From applicants in this field, we would expect great strength on the broader impact criterion as well as demonstrated intellectual excellence and an exceptional, carefully developed research plan.

In short, more physics and astronomy students with more diverse strengths should be encouraged to apply for these fellowships. There is no fixed recipe, no particular combination of ingredients that ensures success. Identifying and encouraging promising students and helping them present themselves effectively benefits both the students and the wider P/A community.

The application deadline for the 2003–04 fellowships is 7 November 2002. Application material is available online at http:www.ehr.nsf.gov/dge/programs/grf/. Our more detailed observations, supporting data, and suggestions are available at http://www.phy.davidson.edu/NSFRF.htm.

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## Looking at Both Sides of Einstein's Gravitational Field Equation

The letter by Alex Harvey (PHYSICS TODAY, February 2002, page 73) claims that the term $\Lambda g_{\mu\nu}$ is necessarily an ingredient of the geometrical, or left-hand, side of Einstein's gravitational field equation. The corresponding matter-free ($T_{\mu\nu} = 0$) solution for $\Lambda > 0$ is the de Sitter space, which contains an embedded repulsive force driving particles apart. Accelerated cosmic expansion therefore appears as a natural consequence of the geometry of space-time. This view conflicts with the "majority opinion" by which the $\Lambda$ term is identified with some kind of "dark energy."

Whichever side of Einstein's equation has $\Lambda$, the equations are still solved by the same curved de Sitter space-time, which contrasts with the flat Minkowski space-time obtained when $\Lambda$ vanishes.

People nevertheless tend to distinguish the two cases because, on the right-hand side, the $\Lambda$ term is another source of gravity, expressed by a constant times the stress-energy tensor ($\kappa T_{\mu\nu}$). Adopting $T_{\mu\nu} = (p + \rho)u_\mu u_\nu + p g_{\mu\nu}$, the form valid for a perfect fluid with energy density $\rho$ and pressure p, one can define a $\Lambda$ fluid by setting $\Lambda = \kappa\rho$. Then the two formulations agree for an equation of state $p = -\rho$.

Because $\Lambda$ is a constant, $\rho$ is constant as well, and such a fluid has negative pressure for positive $\rho$. The relabeling does not change the physics fixed by general relativity: The reformulated cases are equivalent. One should nevertheless be on the alert if $\rho$ is not constant—even a slowly fluctuating field differs from the $\Lambda$ case.

However, as long as $\rho$ is constant, the difference between the two formulations lies only in the language used to describe physically identical situations. General relativists are well acquainted with similar apparent interpretational ambiguities when different coordinate systems are used to describe the same space-time geometry.

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