sured the positions of six stars visible on the plates, but with the 19-year time lapse, he could not rule out proper motion (the projected motion of the stars in the Milky Way) as an explanation of any shift in position. That would be especially true of the particular star field, since the Hyades stars—in which the Sun is located on 28 and 29 May, the dates of the 1900 and 1919 eclipses—are close to our solar system and exhibit large proper motions.

For his six stars, Curtis did use rectilinear coordinates from the Paris zone of the Carte du Ciel project, and he believed they supported his contention that the predicted light-deflection effect was not real. But his data were of poor quality, and William Wallace Campbell, his collaborator and employer at the Lick Observatory, declined to publish the results.

In his letter, McAdory asked whether any astronomers, independent of Einstein, suspected the existence of a shift of star positions near the Sun. One who did believe was Leopold Courvoisier, a Swiss astronomer at the Babelsberg Observatory in Berlin and a colleague of Einstein collaborator Erwin Finlay Freundlich. However, Courvoisier thought the effect extended much farther from the Sun and could be observed without the need for eclipse expeditions. The shift was essentially a seasonal one, he believed, bigger than the one Einstein called for, with the Sun at its center. He was a staunch antirelativist who hated Einstein's theory, and he attributed the effect to the solar system's motion through the ether.

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# Eliminating the GRE

A musician would not take a multiple-choice test to join a band. Yet such tests are how many physics and astronomy graduate programs select students. As a result, departments unintentionally limit the talent that enters the field.

With testing centers closed because of the coronavirus and with concerns about the fairness or the lack[1] of online alternatives, physics and astronomy graduate programs have temporarily stopped using entrance exams to make admissions decisions. I suggest that become a permanent change.

Many faculty members and students believe that the physics Graduate Record Examination (GRE) is one of the most important aspects of graduate admissions.[2] Many programs require a certain score for admission. In theory, a standardized test provides an objective measure for comparing applicants. Everyone takes the same test, so it allows candidates the ability to distinguish themselves by scoring well, or so the argument goes.

But that's not exactly right. With Marcos Caballero, I conducted a study[3] of more than 2500 applicants to five physics programs; we found that doing well on the physics GRE did not result in a higher chance of admission than earning high grades did. In fact, nine times as many applicants are likely to be hurt by a poor physics GRE score despite high grades as are likely to benefit from a high score despite low grades. That discrepancy is in addition to the known test disparities based on gender and race: Women and people of color score lower on the GREs than their white male peers. The differences in scores are because of circumstances, not ability.

Take, for example, stereotype threat. Imagine a Black student hearing her peers say people like her are not good at physics or don't belong in it. If she does poorly on the test, her peers might take it as evidence that they were correct. Now, besides worrying about the test, she worries about proving herself. As a result, she cannot concentrate on the test, and she scores worse than students who didn't worry about stereotypes. The test is hardly a fair method of comparing applicants.

Then there is the expense. While it affects all students, it particularly hurts

those who come from low-income households. Taking the physics GRE requires a $150 fee. If applicants apply to more than four programs, they pay an extra $27 per school to share the test results. Travel costs must be considered as well, because some students may not be near a GRE testing center. Arizona and Nevada, for example, each have only one such site in the state.

If the test provided useful information for admission, perhaps those problems would be tolerable. Medicines have side effects, but medical professionals prescribe them when the benefits outweigh the risks. Such is not the case with the physics GRE. A study of nearly 4000 physics PhD students[4] found only a minor difference between the fractions of high- and low-scoring applicants who completed their PhDs.

Earning a PhD is only one part of being a successful graduate student. Research success is just as important, but the GRE is not helpful in that respect either. One study looked at 149 past recipients of the most prestigious astronomy research fellowships and found that many of them had scored below a typical admissions cut-off on the physics GRE.[5]

Departments would have already removed the physics GRE requirement if doing so were simple. Some faculty members advocate keeping the GRE because they believe it measures something useful. Perhaps departments could compromise and allow applicants to choose whether to submit scores. It seems like having the choice would benefit those who score poorly or who cannot afford to take the test. However, applicants have varying ideas about what "test-optional" means.

As part of a larger 2020 study on physics GRE requirements creating an uneven playing field, researchers from Rochester Institute of Technology interviewed 19 graduate students who had applied to test-optional programs. The 10 women reported submitting their scores, regardless of how well they did, while the 9 men had submitted scores only if they were stellar. So by becoming test-optional, the admissions process may become further biased.

To make the physics graduate school admissions process more equitable, departments must expunge the physics GRE and reenvision how they admit applicants.

Departments could start by admitting students based on their potential instead of their achievement, as recommended in the *Final Report of the 2018 AAS Task Force on Diversity and Inclusion in Astronomy Graduate Education*. Comparing achievements is of limited use when not everyone has the same opportunities.

When conducting research, scientists consider confounding factors that could invalidate their experiments. Admissions committees must do the same when admitting applicants to physics and astronomy programs. Including in evaluations academic achievement and noncognitive skills such as conscientiousness and perseverance can help departments select applicants who can be successful in their programs and do so equitably.

Furthermore, according to an Ohio State University survey, programs that have removed the physics GRE have had more applicants, especially among those identifying as Black, Latinx, and Native American.

The coronavirus has caused departments to rethink how to evaluate applicants. What a great opportunity to remove one of the least equitable parts of the process!

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# Corrections

**October 2020, page 40**—In the caption for figure 1, the increase in the number of physics PhDs at US universities over the past 15 years should be 75%.

**November 2020, page 28**—Daniel Bernoulli, not David, devised a model to predict the benefits of smallpox inoculations. In box 1, the negative binomial distribution should be $P(x; R_0, k) = [\Gamma(k + x)/\Gamma(k + 1)\Gamma(x)]p^k(1 - p)^x$. PT