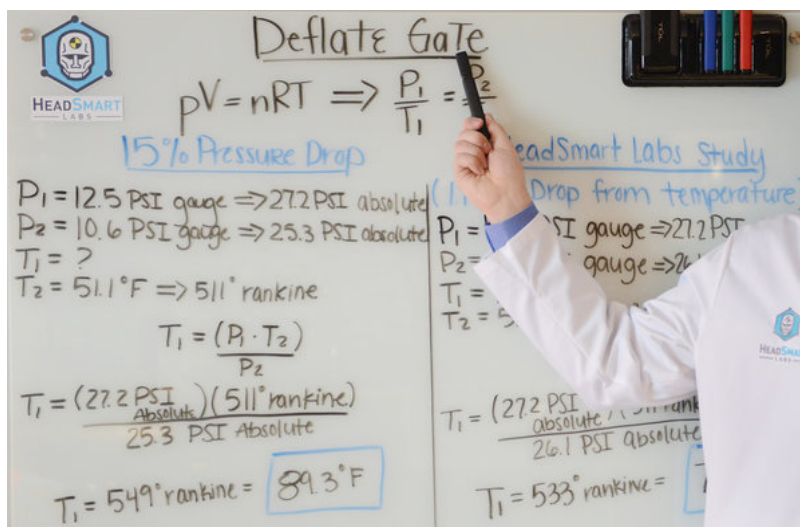


## Deflation Experiments Show Patriots May Have a Point After All

By JAMES GLANZJAN. 29, 2015 Credit Michael Henninger for The New York Times  
HOW IT ALL ADDS UP Thomas Healy, a graduate student at Carnegie Mellon, performed experiments to determine how atmospheric conditions might have affected the Patriots' football. Thomas Healy does not have tickets to the [Super Bowl](#), but he plans to fly to Phoenix with something that is even harder to come by than seats at Sunday's game: the first detailed, experimental data on how atmospheric conditions might have reduced the air pressure in footballs used by the [New England Patriots](#) in their victory over the Indianapolis Colts nearly two weeks ago. Those footballs, which the N.F.L. has said were [deflated to pressures below league standards](#), have created a national meta-bowl whose outcome is seemingly as important as who wins on Sunday. The question driving the public dialogue is whether the Patriots tampered with the balls to make them easier to handle, or whether simply moving them from the warmth of a locker room to the chill and dampness of the field could account for the deflation.

The Patriots have absorbed a beating in that larger contest, with many scientists concluding that only the surreptitious hiss of air being released from the balls could explain the difference. But now the Patriots have started to rally, and in a big way. Healy, who provided The New York Times with an advance copy of [his technical paper](#) on the experiments, concluded that most or all of the deflation could be explained by those environmental effects.

"This analysis looks solid to me," said Max Tegmark, a professor of physics at the [Massachusetts Institute of Technology](#) who reviewed the paper at The Times's request. "To me, their measurements mean that there's no evidence of foul play."



Healy with some of the equations from his paper.

Other evidence is also turning the Patriots' way. In a usually obscure profession that has received extraordinary attention during the controversy, some academic and research physicists now concede that they made a crucial error in their initial calculations, using an equation called the ideal gas law.

When that error is corrected, the amount of deflation predicted in moving from room temperature to a 50-degree field is roughly doubled. Healy, a graduate student in mechanical engineering at Carnegie Mellon University in Pittsburgh, went further: He measured the pressure drop in 12 footballs when they were moved from a room at 75 degrees to one at 50 degrees (the approximate temperature on the field in the Colts game). In the experiment, the deflation of the footballs was close to the larger, correctly calculated value. When Healy moistened the balls to mimic the effects of the rainy weather that day, the pressure dropped even further, close to the deflation of 2 pounds per square inch that the N.F.L. is believed to have found.

Still, several loose ends ensure that the controversy is not close to finished. If the Colts' footballs were properly inflated, as they reportedly were, it might indicate that they were handled differently or inflated more fully to start with. If it turns out that both sets of balls were inflated and handled similarly, the N.F.L. is back to the likelihood that there was tampering by the Patriots.



Max Tegmark, an M.I.T. professor of physics, wrote out the equation, below, which was used in initial calculations in the New England case.

As the Super Bowl approaches, physicists and engineers at some of the nation's most prestigious research institutions have been put into an unaccustomed spotlight as they try to resolve the issue. The Times [reported on Tuesday](#) that N.F.L. investigators had contacted the Columbia physics department for help with "matters relating to gas physics and environmental impacts on inflated footballs.

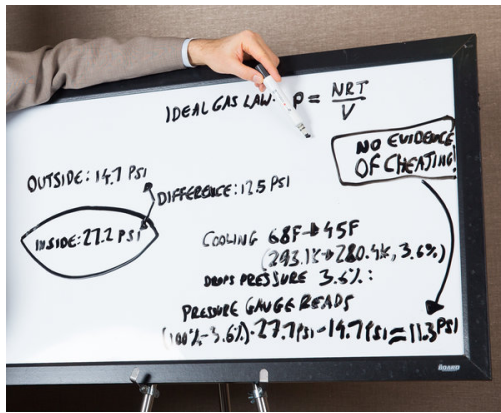
Alan Nathan, a nuclear physicist at the University of Illinois at Urbana-Champaign, who is known for his work in the physics of baseball, said that field had not garnered such interest since Sammy Sosa, a Chicago Cubs outfielder, was caught with a corked bat in 2003. Nathan eventually concluded that corking a bat did not make much difference, especially for Sosa's specialty, which was hitting home runs.

"It's probably much ado about nothing," Nathan said of the football controversy. "I would be pretty surprised if the N.F.L. takes any serious action on this."

Some physicists welcomed the attention to a field usually obsessed with particles that most people would find unpronounceable and equations that were less understandable than colloquial Mandarin.

"The fact that the word 'physics' appears in the sports pages is something that I wouldn't have expected," said Rocky Kolb, dean of physical sciences at the University of Chicago, "so that makes me happy."

When the football controversy arose, a number of physicists cited the ideal gas law, which many of them taught in introductory courses. But applying the equation to real situations can be surprisingly deceptive. When a gauge indicates that the ball contains 12.5 p.s.i. — the minimum allowed by the N.F.L. — the actual pressure is more than twice that amount because the surrounding pressure of the atmosphere must be considered.



Tegmark used a photographer's white board to explain the Ideal Gas Law. This roughly doubles how much a dip in temperature can lower the pressure. During a phone conversation, even Tegmark, the M.I.T. professor, initially used the lower value until recognizing the mistake. "I stand corrected," he said, adding, "It's pretty funny that the ideal gas law is making headlines."

Timothy Gay, an experimental physicist at the University of Nebraska-Lincoln who once wrote a book called "The Physics of Football," with a foreword by Bill Belichick, the Patriots' coach, said there was no doubt that a slightly deflated ball would be easier to grip. But he said his own calculations and Healy's paper, a few details of which had previously leaked out, persuaded him that the weather could account for the pressure drop.

Photo



DEFLATION Timothy Gay, a professor at the University of Nebraska-Lincoln. He has a book called "The Physics of Football."

Belichick and Tom Brady [have denied tampering](#) with a football, but Belichick may have undermined his case with a confusing appeal to scientific principles [in a news conference Saturday](#). "Belichick's press conference raised exactly the correct issues, inarticulate as it was," Gay said.

Healy, 22, is an entrepreneur as well as a graduate student. He founded an independent lab, HeadSmart, which he said was created to study ways in which football helmets could better prevent concussions. He was also a punter on Carnegie Mellon's football team until leg injuries forced him to stop playing.

When the football controversy began, Healy said, the lab had most of the necessary equipment for the new experiments. The team has also started looking at other effects that could be important, including commercial pumps that often spit out air as hot as 130 degrees. When the air cools, that could affect the deflation as well, he said.

Healy, who is from the Boston area, conceded that he would be rooting for the Patriots — whether he gets tickets or not — but said engineers who were not Patriots fans had helped

with the experiments. He said his interest was just in the science.  
“It’s bringing science to a really public light, especially when everybody is getting interested in the Super Bowl,” Healy said.