quite agree with Ashrafi that Farmelo's book is "fascinating" and "thoroughly researched," since I counted 1494 reference notes distributed across its prologue and 31 chapters, I was consequently astonished to find two significant errors concerning the history of relativistic cosmology in the 1920s.

In chapter 19, after describing Georges Lemaître's commencing his studies with Arthur Eddington in 1923 and his cosmology work of 1927, Farmelo says, "Quite independently, the Russian mathematician Alexander Friedmann had applied Einstein's general theory of relativity to the universe as a whole and demonstrated that some mathematical solutions of the equations correspond to an expanding universe, though his work was published only in Russian and at first went unnoticed." No reference note is given, perhaps because the latter two assertions about Friedmann's work are incorrect and, in absence of date of publication, possibly misleading with respect to priority of publication.

Friedmann's first published paper on the subject[1] was written in German and titled "Über die Krümmung des Raumes" ("On the Curvature of Space"). It was not only noticed but criticized later that year by Einstein, who thought Friedmann had made a mistake.[2] Following a visit by Friedmann's colleague Yuri Krutkov and a letter from Friedmann himself, Einstein withdrew his criticism the following year and accepted Friedmann's work as "both correct and clarifying."[3] Although those historical errors have no bearing on Dirac's life, nevertheless, as he would have emphasized, it is important to get it right.

WATER IS DISCOVERED ON THE MOON.

References

1. A. Friedmann, *Z. Phys.* **10**, 377 (1922).
2. A. Einstein, *Z. Phys.* **11**, 326 (1922).
3. A. Einstein, *Z. Phys.* **16**, 228 (1923).

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The need for nondestructive sampling

In their gathering of data, scientists need to be careful that they don't irrevocably pollute the object or area they seek to study. We are particularly concerned about a NASA Moon mission in 2009.

It is fairly common knowledge that the Antarctic and Greenland ice caps are the archives of Earth's climatic history of the past million years. As the ice formed, it trapped air bubbles. From ice cores drilled today, researchers can use refined analysis techniques to recover information about past atmospheric composition, world temperature, ice extent, winds, volcanic eruptions, and other topics.

In the future, even more advanced techniques will allow the extraction of additional information that is archived in the ice. That discovery will be possible because the drilling of ice cores now does not destroy the ice caps.

In interplanetary space, water molecules have existed for millennia. Dust particles varying greatly in size and composition travel in circumsolar orbits together with molecules of both inorganic and organic material. A small fraction of those objects fall on planetary surfaces, including Earth's and the Moon's. Most of those that land on Earth are diluted in the atmosphere, in the oceans, and on the planet's surface. The search for such extraterrestrial objects here is therefore hopeless, except for a few special cases.

Objects falling on the Moon have a different fate. They are unimpeded by atmosphere, winds, or oceans. Water molecules will be absorbed on the rocky and sandy surface, to be desorbed later by solar radiation. Due to the Moon's low gravity, the escape velocity of water molecules is low enough to allow a continuous loss into space. With such conditions, one would not expect to find many water molecules on the lunar surface.

Nevertheless, there are exceptions. Molecules hitting inside small craters near the poles may find a good, protected location; there are certainly small spots that solar radiation will never reach. In those spots there may be interplanetary dust particles and organic or inorganic molecules glued together by frozen water, having accumulated possibly since the Moon was first formed. Those tiny spots are an archive of solar-system history.

In October 2009 NASA's Lunar Crater Observation and Sensing Satellite team carried out a new Moon mission whose main objective was to confirm the presence of water ice in a permanently shadowed crater (http://www.nasa.gov/mission_pages/LCROSS/main/prelim_water_results.html). Unfortunately, that fascinating research question was addressed by dropping a 2366-kg "bullet" that destroyed the crater and polluted the impact site. We understand that the damage is a small price to pay for science, but we wonder if NASA considered that future generations of scientists might not want to find those explosives in the Moon's archives.

From the very basic viewpoint of site preservation, NASA's experiment was quite primitive; it destroyed the historical record in that location. Scientists over the next few hundred years will develop new analysis techniques. They would, we are sure, be glad to find at least part of the natural archive left intact. Subsequent lunar water experiments should be planned as nondestructive site samplings.

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Correction

June 2010, page 60—References 2 and 3 in Robert J. Burke's letter were inadvertently reversed. ■