NEWS

In Brief

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East coast earthquake Shaking from a 23 August magnitude 5.8 earthquake that occurred in the Central Virginia Seismic Zone 135 kilometers southwest of Washington, D. C., was recorded all the way from Georgia to New England, according to the U.S. Geological Survey (USGS). The earthquake caused property damage near the epicenter and also damage to a number of other structures including the Washington Monument and Washington National Cathedral. There was no damage to the AGU headquarters building in downtown Washington, according to building engineer Matthew Boyd. The strongest earthquake ever recorded in Virginia was a magnitude 5.9 quake in 1897. For more information, see http://earthquake.usgs.gov/earthquakes/. —RS

EPA scientific integrity policy draft The U.S. Environmental Protection Agency (EPA) issued its draft scientific integrity policy on 5 August. The draft policy addresses scientific ethical standards, communications with the public, the use of advisory committees and peer review, and professional development. The draft policy was developed by an ad hoc group of EPA senior staff and scientists in response to a December 2010 memorandum on scientific integrity from the White House Office of Science and Technology Policy.

The agency is accepting public comments on the draft through 6 September; comments should be sent to osa.staff@epa.gov. For more information, see http://www.epa.gov/stpc/pdfs/draft-scientific-integrity-policy-aug2011.pdf. —RS

Balancing family and work More than 45% of women scientists at top universities in the United States have indicated that their careers have kept them from having as many children as they want, according to an 8 August study, "Scientists want more children," which appears in the journal *PLoS ONE*. The study, by sociologists Elaine Howard Ecklund of Rice University and Anne Lincoln of Southern Methodist University, indicates that 24.5% of male scientists surveyed indicated the same concerns.

The study also found that among junior scientists, 29% of women indicated concern that a science career would prevent them from having a family; 7% of men indicated the same concern.

Also, graduate students who have had fewer children than they desired are 21% more likely to report considering a career outside science, and postdoctoral fellows are 29% more likely to consider an outside career, Lincoln noted.

"This study has particularly important implications for early career scientists at top research universities, those who will guide the future of science in the United States. Given these findings, universities would do well to reevaluate how family friendly their policies are," Ecklund indicated. For more information, see http://dx.plos.org/10.1371/journal.pone.0022590. —RS

—RANDY SHOWSTACK, Staff Writer

FORUM

Atomic Oxygen Emission Intensity Ratio: Observation and Theory

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What constitutes reality: observation or theory? In the search for truth, observations can sometimes diverge from theory, forcing scientists to rethink fundamental approaches and question the idea of what it means for a system to exhibit "standard" behavior. In this Forum we argue that agreement among theoreticians on the numerical value of a particular physical parameter must still withstand the test of observation.

Airglows

An example of an observation-theory disconnect that has recently risen to prominence is related to airglow observations. The airglow is the faint light that originates with the interaction of upper atmospheric atoms and molecules, directly or indirectly, with solar photons and photoelectrons. The atomic emission lines that are seen in airglows (and in aurorae) are often the same as those seen by astronomers in the cosmos, and of particular concern here are atomic oxygen emissions. Because of their importance in astronomy, the spectral characteristics of these emissions have been extensively studied theoretically, and the resultant database is generally much larger than that from observations.

With recent observational advances in the relevant airglow processes, we are able to make comparisons to theoretical results. Most useful in this endeavor is to find a pair of oxygen emission lines that are forced by quantum mechanics to have a fixed intensity ratio. The pair of lines at 557.7 and 297.2 nanometers fits this description, because both lines arise from the same initial energy level, and thus the fraction of energy going into each radiating channel is fixed. The atomic oxygen levels and the emission wavelengths are illustrated in Figure 1.

An increasingly compelling divergence has developed between the experimental and theoretical values for the intensity ratio. It is interesting to review the historical evolution and consequences of independent determinations of this physical parameter by experimentalists and theoreticians.

Forbidden Transitions

The characteristic emission line at 557.7-nanometer wavelength was first measured by the renowned spectroscopist A. J. Ångström in an aurora [*Ångström,* 1869], and over the years this feature has become known as the atmospheric green line. Not until 6 decades later was its origin as an emission from oxygen established, and by 1928 laboratory studies had succeeded in showing that the emission arises from the transition of oxygen from its ^1S energy level down to the ^1D energy level [$O(^1S \rightarrow {}^1D)$] (see Figure 1). These studies were the first demonstration that metastable states of atoms could emit light [*McLennan,* 1928]. By 1933 the wavelengths and assignments for the $O(^1D \rightarrow {}^3P)$ nebular red line (630.0 nanometers) and the $O(^1S \rightarrow {}^3P)$ transauroral line (297.2 nanometers) were also known [*Boyce et al.,* 1933].

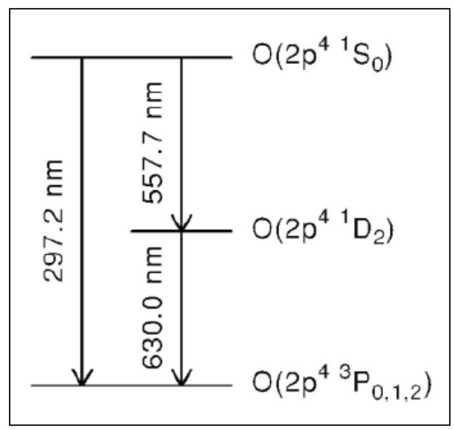

Fig. 1. Energy levels and optical emission wavelengths in atomic oxygen.

All of these emissions are examples of low-probability events known as "forbidden transitions," which are optical transitions that occur despite being unfavorable according to quantum mechanics. The 557.7- and

297.2-nanometer emission lines are characteristic features not only of the terrestrial atmosphere but also of the atmospheres of Venus and Mars [*Slanger et al.*, 2001; *Huestis et al.*, 2010] and, by extension, of any extrasolar planets having oxygen/nitrogen (O_2/N_2) or carbon dioxide (CO_2) atmospheres.

The 297.2-nanometer O($^1S \rightarrow {}^3P$) transition is weaker than the 557.7-nanometer O($^1S \rightarrow {}^1D$) transition, and the value of their intensity ratio extracted from the National Institute of Standards and Technology (NIST) tables is 16.7 (see http://physics.nist.gov/PhysRefData/ASD/lines_form.html), based mainly on the theoretical calculations referenced in Table 1.

In-Flight Spectrometer Calibration

The fact that these two related oxygen lines can be seen in the atmosphere suggests a method of instrumental calibration for space vehicles. Space-based spectrometers are calibrated before spacecraft launch. Once in orbit, it is necessary to recalibrate for possible changes in detector response. This is often done by comparison against the spectra of "standard" stars, but it is advantageous to complement the procedure using the technique proposed here, a measurement across a wide wavelength region using the 557.7- and 297.2-nanometer line pair. There are few examples of spectral features in nightglow, in aurorae, or in other optical emissions that can be used for such a purpose, so accurate knowledge of this atomic oxygen ratio is crucial. In the past, the theoretical ratio has typically been used in atmospheric modeling, but Table 1 shows that there is a surprising discordance between theory and observations for this ratio.

An initial indication that the calculations were not on firm ground came from a rocket measurement of spectral features in the nightglow (the atmospheric glow seen in the absence of solar input). From these measurements an estimate of 9 for the ratio was determined [*Sharp and Siskind,* 1989]. This was subsequently followed by an analysis in which data from various sources were combined, resulting in a value of 9.8 ± 1.0 [*Slanger et al.,* 2006]. There are now two new determinations for the ratio between the intensities of the 557.7- and 297.2-nanometer lines, 9.3 ± 0.5 and 9.5 ± 0.5, in aurorae [*Gattinger et al.,* 2009, 2010] (in all cases analyzed in photon units), which are shown in Table 1. As these measurements are from separate space-based atmospheric observations, such good agreement suggests that the ratio is now well known and should be viewed as a criterion for spectral calibration between the ultraviolet and visible regions by aeronomers. Significant deviation from the recommended ratio of 9.4 ± 1.0 would suggest inadequate instrumental intensity calibration.

Theoretical Considerations

The relatively large discrepancy between observation and theory seen in Table 1 has been quite surprising and emphasizes the uncertainties inherent in making calculations on forbidden transitions. Theoretical quantum mechanical calculations of the energies and properties of atoms and molecules typically rely on variational optimization of the calculated energies of the electronic states, using trial wave functions represented by a sum over numerous electronic structure configurations. Modern computer codes are sophisticated, fast, easy to use, and quite reliable for calculating energy levels. However, they can be less reliable for calculating properties such as radiative emission rates, especially when these rates are small, as they are for the forbidden oxygen transitions in question.

In summary, we conclude that more study is required to bring theoretical determinations into line with experimental data for the neutral atomic oxygen emissions shown in Figure 1, with similar consideration being given to other atomic systems involving forbidden transitions that are of interest to astronomers. Furthermore, we believe that the experimental oxygen transition probability ratio should be accepted as the basis for a space-based two-point calibration system for optical instruments operating in the 290- to 560-nanometer spectral region.

Table 1. Intensity Ratio ($I_{557.7}/I_{297.2}$) of the Atomic Oxygen Emission Lines: Theoretical and Observational Determinations

Source	Ratio
Theory	
Condon [1934]	11.1
Pasternack [1940]	24.4
Garstang [1951]	16.4
Yamanouchi and Horie [1952]	30.4
Garstang [1955]	17.6
Froese Fischer and Saha [1983]	13.6
Baluja and Zeippen [1988]	15.9
Galavis et al. [1997]	14.2
Froese Fischer and Tachiev [2004]	16.1
See http://physics.nist.gov/PhysRefData/0ASD/lines_form.html; National Institute of Standards and Technology from transition probability recommendations	16.7
Nightglow/Aurorae	
Sharp and Siskind [1989]	~9
Slanger et al. [2006]	9.8 ± 1.0
Gattinger et al. [2009]	9.3 ± 0.5
Gattinger et al. [2010]	9.5 ± 0.5
New recommendation	9.4 ± 1.0

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MEETING

Addressing Socioeconomic and Political Challenges Posed by Climate Change

NATO Advanced Research Workshop: Climate Change, Human Health and National Security; Dubrovnik, Croatia, 28–30 April 2011

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Climate change has been identified as one of the most serious threats to humanity. It not only causes sea level rise, drought, crop failure, vector-borne diseases, extreme events, degradation of water and air quality, heat waves, and other phenomena, but it is also a threat multiplier wherein concatenation of multiple events may lead to frequent human catastrophes and intranational and international conflicts. In particular, urban areas may bear the brunt of climate change because of the amplification of climate effects that cascade down from global to urban scales, but current modeling and downscaling capabilities are unable to predict these effects with confidence.

These were the main conclusions of a NATO Advanced Research Workshop (ARW) sponsored by the NATO Science for Peace and Security program. Thirty-two invitees from 17 counties, including leading modelers; natural, political, and social scientists; engineers; politicians; military experts; urban planners; industry analysts; epidemiologists; and health care professionals, parsed the topic on a common platform.

Participants noted that drought and changing rainfall patterns may exacerbate food and water shortages, especially in Third World countries that are already afflicted with poverty and hunger. This, in turn, may create humanitarian crises such as pandemics, transmigration, and conflicts, thus threatening the security of individuals and nations. Citizen demands for essential goods and services may outstrip the ability of governments to meet those demands, leading to extremism, radical ideologies, terrorism, and authoritarianism. Exacerbated climate impacts in urban areas, where anthropogenic stressors are most prevalent, may endanger their very sustainability. Large cities, notably megacities, are susceptible to conflict origination, for which climate woes are a catalyst. Minimum nighttime temperatures in cities are increasing faster than global averages, which, together with the urban heat island effect, makes cities more energy intensive, pollution prone, and susceptible to human health travails. Poor and at-risk communities are the most vulnerable, and marginalization fueled by social injustice feeds into existing conflicts and grievances.

The web of socioeconomic and political challenges posed by climate change can be addressed only by interdisciplinary approaches, and this workshop was exemplary of how different communities can work together in seeking solutions. The attendees called for more openness of climate data, including raw data, to avoid future “climategate” crises that mislead the public. Inclusion of voluntary data, further development of physics-based data acceptance or rejection protocols (vis-à-vis those based on perceived trends), and improved data sharing and archiving practices should be considered, for which international organizations such as the World Meteorological Organization, United Nations, and World Health Organization can be facilitators.

The attendees pondered ways of converting “potential conflicts to cooperation.” Air and water can be powerful resources for fostering peace, allowing climate change discourse among stakeholders at local levels, which has been largely neglected, to be a palliative and stimulus. Implementing cutting-edge technology for resilient and green infrastructure, reducing greenhouse gas emissions, resettling communities, issuing environmental hazard warnings, and promoting education at all levels are some solutions participants noted. The future of climate science relies on intellectual and pedagogical advances undergirded by high-quality data and improved predictive modeling.

The workshop proceedings will be published in a special ARW volume. For further details, see http://www.nd.edu/~dynamics/NATOWorkshop.htm.

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