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Status of the draft ISO Solar Irradiance Standard

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Abstract. The International Standards Organization (ISO) is developing a solar irradiance standard to specify the representations of solar irradiances. It is applicable to measurements, reference spectra, empirical models, and first-principles models. Its purpose is to provide a standard specification of all solar irradiances for use by space systems materials and environment. The standard development process, the participants and owners of that process, the scope, concept, assumptions underlying this particular standard, and the ISO solar irradiance standard itself are described. © 2000 Elsevier Science Ltd. All rights reserved

1 Standard overview: development, participants, and scope

Solar irradiances derive from measurements and/or models and are frequently reported to space systems users. Because solar irradiances are crucial for understanding a wide variety of physical processes and technical issues, and because irradiances have been reported in a variety of formats, it has been recognized that a standardization of irradiance specification is important. Standardized specification of solar irradiances also provides users with a recognizable method of properly using all solar irradiance products.

The International Standards Organization (ISO) Technical Committee 20, SubCommittee 14, Working Group 4 (TC20/SC14/WG4) met during the fall 1997 in St. Petersburg, Russia. From that meeting, the working group requested that scientific experts in the solar irradiance measurement and modeling community assist the ISO working group in developing a solar extreme ultraviolet (EUV) standard. The initial concept of the work would be to standardize solar EUV irradiances as related to space systems. Anatoliy A. Nusinov (Russia) and W. Kent Tobiska (United States) were subsequently designated the project co-leads for this standards activity.

An initial concept for the standard was presented in the Beijing (May, 1998) and a formal ISO New Work Item (NWI) was accepted by Working Group 4 in Yokohama (September, 1998). In Turin (May, 1999), the Working Group changed the scope of the standard to encompass a standard for the full solar spectrum. The NWI title was redefined at that meeting as "Space Systems - Process for determining solar irradiances." Following a Working Group meeting at Kennedy Space Center (September, 1999), the revised New Work Item Form 4 was ready for balloting by ISO delegates as sub-stage 10.00.

Currently, the project co-leads are developing a Working Draft (WD) for presentation to and comments solicited from the science communities and ISO working group delegates. The WD will be ready at the London TC20/SC14 meeting (June, 2000) and will be designated an ISO substage 20.00 activity. A Committee Draft (CD) will be developed during 2000-2001 to be discussed by TC20/SC14 and designated substage 30.00 while a Draft International Standard (DIS) will be developed during 2002 at substage 40.00. The Final Draft International Standard (FDIS) will be discussed among ISO member delegations during 2003 at substage 50.00 with a formal acceptance as an International Standard and publication occurring in 2004 at substage 60.00.

The process owner of this activity is ISO TC20/SC14/WG4 and the participants in this process are delegates to ISO TC20/SC14/WG4 and the international solar science community.

The scope of standard specifies the representations of solar irradiances and is applicable to measurements, reference spectra, empirical models, and first-principles models. Its purpose is to provide a standard specification of all solar irradiances for use by space systems materials and environment.

During the evolution of this standard, it is anticipated that there will be a parallel development, for certification, of measurements, reference spectra, and models.

2 Concept and assumptions

The concept of an ISO solar irradiance standard is based on the assumption that there will be continued technical improvements in the accuracy and precision of measurements

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as space-based instrumentation uses new detectors, filters, and computer hardware/software. There is also the expectation of continual improvements to reference spectra, empirical, and first-principles models. In addition, it is likely that there will be an evolving solar standard user community that is still not fully defined.

Because of the anticipated continued change, the ISO solar irradiance standard is being written as a "process-based" standard. In other words, a solar irradiance product would be developed to "comply" with the standard rather than the standard dictating one spectrum or one model as the prime product.

3 Solar irradiance types

Solar irradiance types are established to provide the user community with an easy-to-recognize method of identifying a standard-compliant irradiance product. Products of the solar radiation state that can be assigned a type include measurements, reference spectra, empirical models, and first-principles models. An irradiance product complies with only one type.

1) Type 1 is a compliant measurement set,
2) Type 2 is a compliant reference spectra,
3) Type 3 is a compliant empirical model, and
4) Type 4 is a compliant first-principles model.

4 ISO solar irradiance standard

The project co-leads have developed a compliance list with four overarching themes that are common to radiation state measurements, reference spectra, empirical models, and first-principles models. They are:

1) solar irradiances are reported in SI units of Watts per square meter corrected to 1 AU;
2) the method of determining irradiances is documented and, where appropriate, includes data collection, processing, archiving, validation, accuracy, and precision methodology and/or algorithms information as well as:
   a) for measurements (e.g., space-based satellite observations or rocket experiment datasets), a description of the instrumentation used to obtain and return the fluxes and the instrument calibration technique and heritage,
   b) for reference spectra (e.g., the mean of spectra over several solar cycles or spectra for low, moderate, or high solar activity conditions), a description of the measurement sets, the method of resolving discrepancies, and the rationale for specification as a reference,
   c) for empirical models (e.g., based on one or many space-based measurement sets), a description of the proxies and independent datasets used in the derivation, the mathematical formulation of the model, and the rationale for use of the proxies selected, and
   d) for first-principles models (e.g., models of solar LTE and non-LTE processes), a description of the physical principles of the model and the numerical algorithms.
3) the irradiances documented in item 2 are published in an internationally-available journal which uses scientific or discipline-area peer review in the publication process. For all irradiances, the published article can point to a permanent electronic archival location where the actual archived measurements, spectra, or models can be found; and
4) the irradiances documented in items 2 and published in item 3 are archived in a method consistent with current technology that ensures international accessibility.

5 Solar irradiance spectral categories

Solar irradiance product spectral categories are defined as:

1) hard X-rays (10 nm $> \lambda$),
2) soft X-rays or XUV (30 nm $> \lambda \geq$ 10 nm),
3) extreme ultraviolet or EUV (120 nm $> \lambda \geq$ 30 nm),
4) ultraviolet or UV (400 nm $> \lambda \geq$ 120 nm),
5) visible or optical or VIS (700 nm $> \lambda \geq$ 400 nm),
6) infrared or IR (10 μm $> \lambda \geq$ 0.70 μm),
7) far infrared (1000 μm $> \lambda \geq$ 10 μm),
8) radio wavelengths ($\lambda \geq$ 1 mm),
9) total solar irradiance or TSI (integrated full-disk solar spectrum).

6 Solar irradiance standard certification

Certification of compliance with the standard is achieved by identification of a type as defined above, compliance with the four overarching themes listed above, and identification of a spectral category. Self-declaration of compliance in an archival publication as part of item 3 can be accomplished by using the statement "These *<spectral designation>* solar irradiances are compliant with the *<type designation>* ISO Space Systems - Process for determining solar irradiances International Standard."

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