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Bibliography of Photon Total Cross Section (Attenuation Coefficient) Measurements 10 eV to 13.5 GeV, 1907-1993

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U.S. DEPARTMENT OF COMMERCE
Ronald H. Brown, Secretary

TECHNOLOGY ADMINISTRATION
Mary L. Good, Under Secretary for Technology

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
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Bibliography of Photon Total Cross Section (Attenuation Coefficient) Measurements 10 eV to 13.5 GeV, 1907-1993

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Abstract

A bibliography is presented of papers reporting absolute measurements of photon (XUV, x-ray, gamma-ray, bremsstrahlung) total interaction cross sections or attenuation coefficients for the elements and some compounds. The energy range covered is from 10 eV to above 10 GeV. These papers are part of the reference collection of the National Institute of Standards and Technology Photon and Charged Particle Data Center. They cover the period from 1907 through 1993 and into 1994. Thus this report is an update of the 1986 earlier report NBSIR 86-3461, and also includes additional papers dating back as far as 1966 which have since been found or brought to the attention of the author. Included with each reference are annotations specifying the energy range covered and the substances studied. This updated bibliography now includes 573 non-duplicative references to available measured data, plus 42 references to critical evaluations and review articles.

Key words: attenuation coefficient, cross section, bibliography, gamma rays, photons, x rays.

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1. Introduction

Since 1950 the National Institute of Standards and Technology (formerly National Bureau of Standards) has maintained a data base of measured and theoretical cross section data in the form of reprints, reports, and personal communications. The purpose is to provide photon (XUV, x-ray, gamma-ray, and bremsstrahlung) interaction data required in a variety of medical, industrial, defense, and scientific applications. This data base has been used from time to time for the tabulation of photon cross sections and attenuation coefficients [1-11]. Here is presented a bibliography of the published and unpublished research papers, comprising this data base, reporting measured absolute photon interaction cross sections and attenuation coefficients. This report updates an earlier bibliography by Hubbell, Gerstenberg and Saloman in the report NBSIR 86-3461 (1986)[12].

2. Compilation of the Bibliography

The items included in the bibliography have been acquired from a variety of sources. The archival journals covered by Current Contents have been reviewed both for articles on attenuation coefficients and for articles in which attenuation coefficients have been measured incidentally to their main objective. This report, as in reference [12] draws on previous review articles and bibliographies [13-24]. Also included are unpublished reports and private communications. In cases where there is multiple publication of essentially the same data only one reference is made. No attempt has been made to eliminate anomalous data sets from this listing. The dates of the items in the bibliography range from 1907 through 1993 and into 1994. Table 1 is a summary of the number of items in this bibliography by decade of publication. There are a total of 573 separate references to a total of about 22,000 data points.

3. Description of the Bibliography

This bibliography, as well as the 1986 report [12], is a further updated and enlarged version of the bibliography of reference [25]. The six-character reference symbols are again the same as those of reference [25]. The first two characters are the last two digits of the year of publication (or report). The next two characters are the first two letters of the first author's last name. The final two digits (usually 01) are added to insure uniqueness. The references are arranged in increasing order of year of publication and within each year alphabetically by first author. For each item the reference symbol is at the left margin. Next comes a listing of all authors, the journal title, volume number, pagination and year (or alternate referencing if not a journal article). The title of the article is given on the lines following. On the last line, enclosed in parenthesis, is the photon energy range studied and a listing of the elements measured in order of increasing atomic number as well as a listing of any compounds measured. In addition to an author index, an index to materials covered, arranged by atomic number for elements, and alphabetically for compounds and for named substances, is provided.

4. Discussion

This bibliography has been prepared as part of a critical evaluation of photon absorption cross sections and includes references to all data sets which provide either absolute cross sections or can be converted into absolute cross sections. Not all the data represented by this bibliography are consistent. As can be seen in the graphs of reference [25], in a graphical intercomparison of Pb data by Gerstenberg [26], and in soft x-ray intercomparisons by Saloman et al [27-29], some data sets appear to have substantial systematic errors as compared with the "main stream" of data points or with "reliable" theory. Reference [29] provides both tabular and

graphical comparisons for energies between 10 eV and 100 keV between the data covered in the 1986 bibliography [12], the semi-empirical cross section compilation of Henke *et al.* [14] and the theoretical photoionization values of Scofield [30]. Further evaluations, compilations and status reports on x-ray attenuation coefficients, also on the related quantity, the energy-absorption coefficient, are given in references [31-42].

The materials index at the end of this report will be useful to researchers interested in making new x-ray attenuation measurements to fill gaps in the existing experimental data which are the subject of this bibliography. The four most-measured substances are carbon (106 references), aluminum (179 references), copper (153 references) and lead (136 references). The highest-density element osmium (Z = 76) has yet to be measured, in any photon energy region, perhaps because it is highly toxic as well as otherwise difficult to handle.

5. Request for Additions and Corrections

Since it is desireable that the NIST data base continue to be as up-to-date, accurate, and comprehensive as possible, the author will appreciate receiving any corrections and additions to this work. He will also appreciate receiving copies of any new papers containing photon attenuation coefficient and cross section data.

Acknowledgments

The author thanks Mrs. Gloria Wiersma for her recapture of the bibliography and indexes of the reference [12] into PC machine readable form by means of an optical scanner and for her extensive editing and cross-checking of this material.

TABLE 1

Number of References in the Bibliography by Decade

DECADE	NUMBER OF REFERENCES
1900-1909	2
1910-1919	6
1920-1929	20
1930-1939	49
1940-1949	13
1950-1959	66
1960-1969	169
1970-1979	151
1980-1989	73
1990-1994	24
Total	573

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(5.41-22.16 keV: C, Mg, Al, Fe, Ni, Cu, Zn, Ag, Sn, Pt, Au)

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11Ch01 Chapman, J. C., Philos. Mag. **21**, 446-454 (1911)
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(11.21-28.51 keV: Al)

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The Production of Characteristic Röntgen Radiations
(1.49 keV: Al)

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Bestimmung des Absorptionskoeffizienten für Röntgenstrahlen in der Nähe der K-Absorptionskante der Elemente Cu und Zn
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(0.277 keV: He, C, N, O, Ne, Ar, Kr, Xe, Au, CO_2, Air)

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(8.06-96.94 keV: Sn)

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