

## CHAPTER 2

### RADIOMETRIC AND PHOTOMETRIC CONCEPTS

#### 2.0 Introduction

Having completed our introductory survey of hydrologic optics, we now embark on a theoretical reconstruction of all that we saw and did: we shall now start from scratch.

In this chapter we shall develop the concepts of radiometry and photometry needed in the study of radiative transfer. The mode of approach to these concepts is governed by the particular outlook of radiative transfer theory as it is applied to hydrologic optics. As we have defined it (Sec. 1.0) hydrologic optics is the study of radiative transfer in general hydrosols; and radiative transfer, in turn, employs a phenomenological viewpoint of light. Therefore, the approach to radiometry and photometry in hydrologic optics takes place on a phenomenological level. In other words, the concepts of radiometry and photometry which play a major role in hydrologic optics are those which are defined for natural light fields in which operations have been performed on a macroscopic level and with instruments which in certain key types of response are very similar, qualitatively, to the human eye. Thus, like the human eye, the sizes of the special instruments used in radiative transfer measurements are large compared to the sizes of the wave and particle structures of light and matter. Therefore these instruments do not ostensibly sense and record any of those features of light directly characterizable by its wave or particle structure, such as diffraction and interference features. However, the radiometric instruments used are designed to extend and amplify under precise quantitative control certain selected capabilities inherent in the human eye, foremost of which is the ability to sense and record the various brightnesses of monochromatic light in all directions about a given point in the observer's locale. This, after all is said and done, is the principal goal of classical photometry. The complete route to this goal is necessarily through an intricate maze of psychometric, radiometric, electromagnetic and quantum constructs. However, the paths we shall take to photometry in this chapter can fortunately bypass most of the usual detours along the route, detours which study the manifold conceptual and experimental aspects of the subject. The topics we select for discussion are mainly theoretical and on this level constitute the minimal number just sufficient to allow the logical establishment of those photometric concepts and various radiometric models of natural light fields used in

radiative transfer measurements. We shall stand away from electromagnetic complexity, and half-shut our eyes as we reconstruct radiometry. In the next chapter we shall shut our eyes completely and think about what we have seen in Vol. I.

The outline of this chapter is as follows. We begin in Sec. 2.1 with the operational definition of radiant flux. It is always good practice to give as many means of visualization of a newly defined concept as mutual consistency will allow. For this reason, and also to pave the way for a more versatile presentation of the concepts of hydrologic optics than that of Chapter 1, we develop in Sec. 2.2 the three main ways to conceptually view the notion of radiant flux. The principal properties of radiant flux, as they are used in geometrical radiometry, are developed in Sec. 2.3. Then, in close succession, the principal derived concepts of radiometry are developed: radiance and various forms of irradiance, along with theorems governing and examples illustrating their salient properties. Throughout our development we shall emphasize the *geometrical* aspects of radiometry rather than their physical aspects. The latter aspects, to the degree that we shall need to study them in this work, are reserved for discussion in Sec. 2.1. However, some notice must also be taken of the physical aspects of radiometry in preparing to construct the bridge between radiometric and photometric concepts. Therefore, in Sec. 2.12, we pause to develop those concepts of photometry which facilitate the operational definition of the notion of luminous flux--the photometric counterpart to radiant flux. With the radiometric discussions as a model, the various derived photometric concepts are then readily attained. The chapter closes with some remarks on generalized photometric concepts.

Our present viewpoint of geometrical radiometry and photometry may then be summarized in the following definitions of these disciplines, which we adopt: *Radiometry is the science of the measurement of radiant energy. Geometrical Radiometry is the union of euclidean geometry and Radiometry: it measures and describes the flow of radiant energy of given frequency through volumes, across surfaces, along lines, and at points in space. With this in mind we can go on to say that: Geometrical Photometry measures the visual, erythemal, photoelectric, or photographic response, by given receptors, to the quantities of geometrical radiometry, with respect to different frequencies of radiant energy.*

## 2.1 Radiant Flux

We now take up the details of an operational definition of radiant flux. The heart of the definition we shall adopt consists of the postulation of some physical device which can sense and record in quantitative detail the presence of light--or radiant energy in general--in a neighborhood of a point in space. There are several devices available for such a purpose. Of those currently available, the photoelectric devices are most satisfactory from the point of view of sensitivity and quantitative precision. We pause briefly to survey this class of devices.