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A photometric unit for the airglow and aurora

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Abstract—It is suggested that the angular surface brightness B of these sources be measured in units of 10^6 quanta/cm^2 sec sterad. The number quoted should be $4\pi B$, and the unit of $4\pi B$ should be called the rayleigh. The advantages of this convention are pointed out and typical values of $4\pi B$ for the night and twilight airglow and the aurora are given.

RECENT discussions among the writers have shown that there is a need for agreement on a well-defined unit for photometry of the airglow and aurora. The definition should show clearly how the unit is to be found from observations, and the interpretation in terms of physical processes should be convenient. We believe that the proposal which follows is satisfactory in these regards.

The quantity actually measured is angular surface brightness B, which is most usefully expressed in such units as quanta/cm^2 sec sterad. However, the important quantity when the results are interpreted in terms of physical processes is usually volume emission rate, in quanta/cm^3 sec. This emission rate cannot be found directly from surface-brightness measurements, but the rate of emission from a cm^2 column along the line of sight is ordinarily just $4\pi B$. This relation is true for any isotropic source with no self-absorption; for other sources $4\pi B$ gives a convenient starting-point for further correction. Consider a cylindrical column of cross-sectional area one cm^2 extending away from the photometer; the emission rate from a volume element of length dl at distance l is $\varepsilon(l)$ photons/cm^3 sec. The element contributes to B an amount $dB = \varepsilon(l)\, dl/4\pi$. Integrating along the line of observation gives $4\pi B = \int_0^\infty \varepsilon(l)\, dl$ which is the emission rate from the whole column, as already stated.

Therefore, we propose that photometric measurements of the airglow and aurora be reported in terms of $4\pi B$, rather than the surface brightness B itself. Further, we suggest that $4\pi B$ be given the unit of "rayleigh" (symbol R), where B is in units of 10^6 quanta/cm^2 sec sterad. Hence 1 R $= 10^6$ quanta/cm^2 (column) sec. (The word "column" is often inserted into these units to convey the concept of an emission-rate from a column of unspecified length. As mentioned above, this interpretation of the observations would not be strictly correct in the event of self-absorption or non-isotropic emission, and the use of "column" in the units would then incorrectly imply a rate of emission within the column.) It should be emphasized that the rayleigh can be used as defined without any commitment as to its physical interpretation, even though it has been chosen to make interpretation convenient. Basically it is just the measured brightness multiplied by 4π.

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The unit is of course named after the fourth Lord RAYLEIGH (R. J. STRUTT), who made the first absolute measurement of the intensity of the night airglow (1930). (It is his father, J. W. STRUTT, who is remembered for the theory of molecular scattering, among other things.) RAYLEIGH's result for the zenith was $4\pi B = 1{\cdot}81 \times 10^8$ quanta/cm² (column) sec, or 181 rayleighs. The typical value in Table 1, found by photoelectric photometry, agrees very well with this old result of visual photometry.

Table 1. Typical values of $4\pi B$

Emission	Source	$4\pi B$	
[O I]-5577 Å	Night airglow, zenith	250 R	
	Aurora, I.B.C. I	1 kR	
	II	10 kR	
	III	100 kR	
	IV	1000 kR	
		summer	winter
NaI-5893 Å	Night airglow, zenith	70 R	300 R
	Twilight airglow, zenith	820 R	4300 R

A resolution making these proposals was presented by ROACH to Commission 22a of the International Astronomical Union at the ninth general assembly in September 1955. The present note is intended to clarify some ambiguities in the resolution as well as to amplify the ideas.

Measurements of the airglow have often been given in megaquanta/cm² (column) sec (for example, PETTIT, ROACH, ST. AMAND, and WILLIAMS, 1954). This unit is identical with the rayleigh. Some recent papers by HUNTEN (1955, 1956) have used a unit $Q(\lambda)$ equal to 10^7 quanta/cm² sec sterad. Multiplying numbers quoted in this unit by 40π or 126 transforms them into rayleighs. Some typical brightnesses are given in Table 1. Most of these data have been reported in the publications mentioned above. The scale for the auroral International Brightness Coefficients is a small modification of the one proposed by SEATON (1954), and has already been suggested as a standard (HUNTEN, 1955). It will be noted that the rayleigh is of convenient size for the airglow, and the kilorayleigh for the aurora.

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