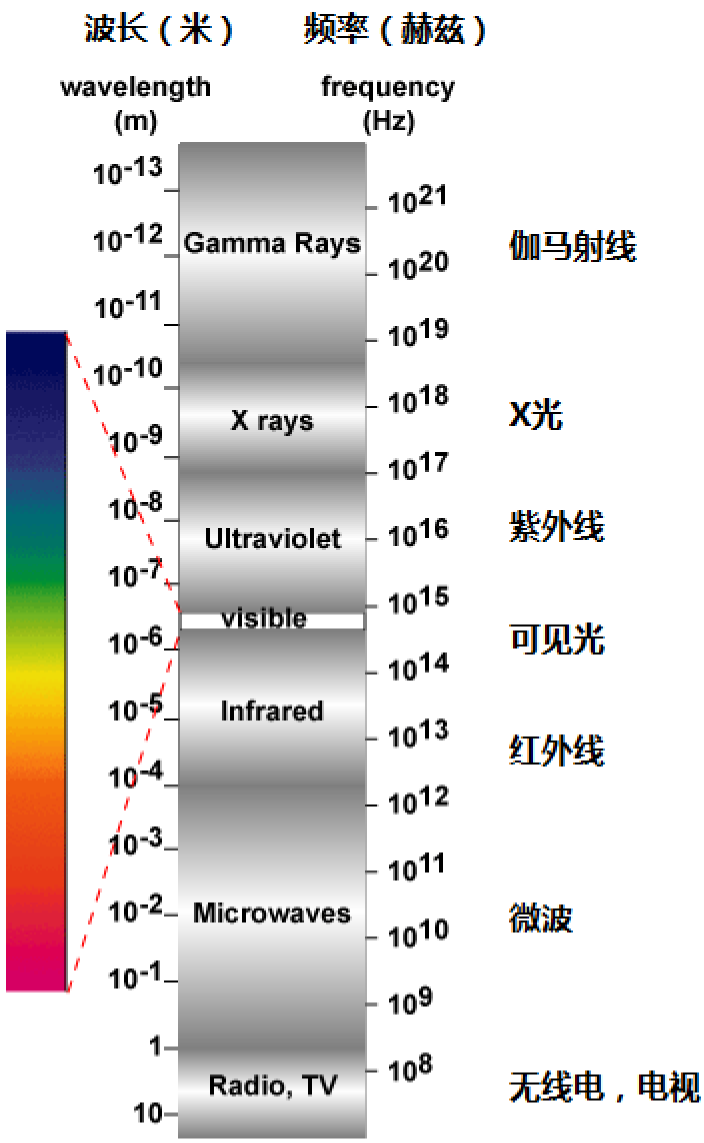
2.1 Properties of Light

光的性质

The light that we see everyday is only a fraction of the total energy emitted by the sun incident on the earth. Sunlight is a form of "electromagnetic radiation" and the visible light that we see is a small subset of the electromagnetic spectrum shown at the right.

我们每天都能见到的光只是太阳照射到地球上的总能量的一部分。太阳光是“电磁波”的一种形式，我们所能看到的光（可见光）只是右图（译者注：原文中为右图，译文中为下图）电磁波谱的一个小的子集。



The electromagnetic spectrum describes light as a wave which has a particular wavelength. The description of light as a wave first gained acceptance in the early 1800's when experiments by Thomas Young, François Arago, and Augustin Jean Fresnel showed interference effects in light beams, indicating that light is made of waves. By the late 1860's light was viewed as part of the electromagnetic spectrum. However, in the late 1800's a problem with the wave-based view of light became apparent when experiments measuring the spectrum of wavelengths from heated objects could not be explained using the wave-based equations of light. This discrepancy was resolved by the works of [1] in 1900, and [2] in 1905. Planck proposed that the total energy of light is made up of indistinguishable energy elements, or a quanta of energy. Einstein, while examining the photoelectric effect (the release of electrons from certain metals and semiconductors when struck by light), correctly distinguished the values of these quantum energy elements. For their work in this area Planck and Einstein won the Nobel prize for physics in 1918 and 1921, respectively and based on this work, light may be viewed as consisting of "packets" or particles of energy, called photons.

电磁波谱把光描述成具有特定波长的波。把光描述成波的这一理论在 19 世纪初第一次被接受。托马斯·杨，弗朗索瓦·阿拉戈和奥古斯丁·菲涅耳的实验证实了光束之间的干涉效果，表明光是由波构成的。直到 19 世纪 60 年代末，光都被看做电磁波谱的一部分。然而到了 19 世纪末，人们发现基于光的波动性的公式无法解释被加热的物体的波谱的测量结果，这暴露出了光的波动性学说的问题。直到 1900 年 [1] 和 1905 年 [2]，实验结果和理论的不一致才被解决。普朗克提出，光的总能量是由无法分割的能量元（或者说是一份能量）构成的。爱因斯坦在研究光电效应（金属和半导体在光照下释放出电子的现象）的时候准确的区分出了这些量子能量元的值。普朗克和爱因斯坦因为在这一领域内的工作分别在 1918 年和 1921 年获得了诺贝尔物理学奖。根据他们的研究成果，光是由一份一份被称为光子的能量粒子构成的。

Today, quantum-mechanics explains both the observations of the wave nature and the particle nature of light. In quantum mechanics, a photon, like all other quantum-mechanical particles such as electrons, protons etc, is most accurately pictured as a "wave-packet". A wave packet is defined as a collection of waves which may interact in such a way that the wave-packet may either appear spatially localised (in a similar fashion as a square wave which results from the addition of an infinite number of sine waves), or may alternately appear simply as a wave. In the cases where the wave-packet is spatially localised, it acts as a particle. Therefore, depending on the situation, a photon may appear as either a wave or as a particle and this concept is called "wave-particle duality". A wave-packet, or photon is pictured as used in PVCDROM below.

在今天，量子力学可以解释了我们所观察到了光的波动性和粒子性。在量子力学中，光子和其他粒子(比如电子和质子)一样，被最准确的描绘为波包。波包被定义为很多波的集合，这一集合中的波之间的相互作用使得波包或者表现出空间的局域性（就像方波是由无数的正弦波叠加形成的那样）或者就只是表现波的性质。当波包呈现空间的局域性时，它就表现出粒子性。因此，基于这一条件，光子既可能以波的形式存在也可能以粒子的形式存在。这一概念被称作“波粒二象性”。波包，或者说光子被描绘成下文的样子。

High energy photon for blue light. 

蓝光光子具有高能量

Lower energy photon for red light. 

红光光子具有低能量

Low energy photon for infrared light.
Should be invisible! 

红外光的光子的能量更低，并且应当是不可见的。

A complete physical description of the properties of light requires a quantum-mechanical analysis of light, since light is a type of quantum-mechanical particle called a photon. For photovoltaic applications, this level of detail is seldom required and therefore only a few sentences on the quantum nature of light are given here. However, in some situations (fortunately, rarely encountered in PV systems), light may behave in a manner which seems to defy common sense, based on the simple explanations given here. The term "common sense" refers to our own observations and cannot be relied on to observe the quantum-mechanical effects because these occur under conditions outside the range of human observation. For further information on the modern interpretation of light please refer to [3].

因为光是由一种被称为光子的量子力学粒子构成的，所以为了给出光的性质的完整的物理描述，我们需要引入对光的量子力学分析。对于光伏应用来说，我们并不需要了解到这种程度。因此，本文对于光的量子性质只提及了寥寥数句。但是，在一些情形下（幸运的是，这些情形很少在光伏系统中出现），基于本文中给出的简略解释，光可能会表现得和人们的常识不太一样。所谓“常识”是通过我们自身的观察获得的，所以我们不能依靠常识来观察量子力学效应，因为它不在人类观察能力范围之内。更多有关光的现代解释请参考 [3]。

There are several key characteristics of the incident solar energy which are critical in determining how the incident sunlight interacts with a photovoltaic converter or any other object. The important characteristics of the incident solar energy are:

- the spectral content of the incident light;
- the radiant power density from the sun;
- the angle at which the incident solar radiation strikes a photovoltaic module; and
- the radiant energy from the sun throughout a year or day for a particular surface.

By the end of this chapter you should be familiar with the above four concepts.

入射的太阳能量有一些非常重要的特性，这些特性在很大程度上决定了入射的太阳光将如何与光伏转换器或者其他物体相互作用。这些特性包括：

- 入射光的光谱内容
- 太阳辐射的能量密度
- 入射太阳辐射与光伏组件之间的夹角以及
- 太阳在某个特定表面的年辐射量或日辐射量

原文地址：http://www.pveducation.org/pvcdrom/properties-of-sunlight/properties-of-light
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在这一章节的最后，您将熟悉以上四个概念。

参考文献

1. Planck M. Distribution of energy in the normal spectrum. Verhandlungen der Deutschen Physikalischen Gesellschaft. 1900;2:237-245.

2. Einstein A. Generation and transformation of light. Annalen der Physik. 1905;17.

3. Feynman RP. QED : The Strange Theory of Light and Matter.; 1985.