2.12 Air Mass

空气质量

The Air Mass is the path length which light takes through the atmosphere normalized to the shortest possible path length (that is, when the sun is directly overhead). The Air Mass quantifies the reduction in the power of light as it passes through the atmosphere and is absorbed by air and dust. The Air Mass is defined as:

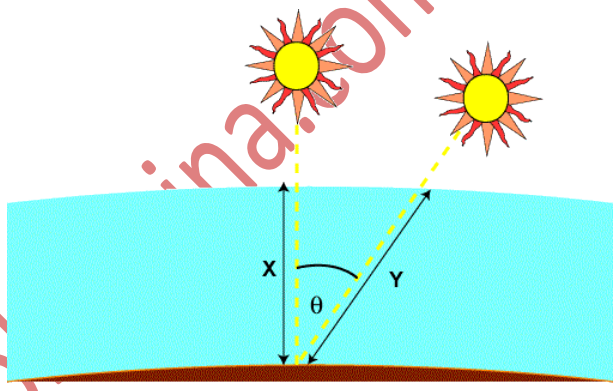
$$AM = 1/\cos(\theta)$$

where θ is the angle from the vertical (zenith angle). When the sun is directly overhead, the Air Mass is 1.

空气质量是光线穿过大气层的路程与最短的可能路程（也就是当太阳正好在头顶的时候）的比值。空气质量用于量化当光线穿过大气层时由于空气和尘埃的吸收而减少的能量。空气质量通过下面的公式定义：

$$AM = 1/\cos(\theta)$$

公式中，θ 表示太阳位置与垂直方向间的夹角（天顶角）。当太阳正好在头顶时，空气质量为 1。



The air mass represents the proportion of atmosphere that the light must pass through before striking the Earth relative to its overhead path length, and is equal to Y/X.

空气质量描绘了光线到达地球表面之前通过的路程与太阳处于头顶时的路程的比例，其值等于 Y/X。

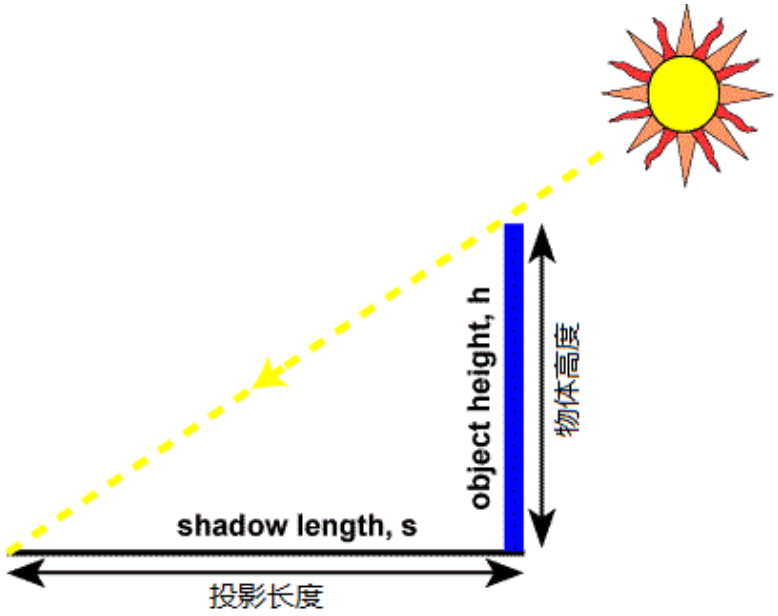
太阳位置-空气质量计算器

Sun Position - Air Mass Calculator

输入太阳位置与垂直方向的夹角			空气质量		
Enter the angle from vertical, θ =	30	°	Air mass, AM =	1.1547	units

An easy method to determine the air mass is from the shadow of a vertical pole.

一个简便计算空气质量的方法是测量垂直标杆的投影高度。



Air mass is the length of the hypotenuse divided by the object height h, and from Pythagoras's theorem we get:

$$AM = \sqrt{1 + \left(\frac{s}{h}\right)^2}$$

空气质量是三角形的斜边除以物体高度 h，通过毕达哥拉斯定理（译者注：勾股定理），我们可以得到：

$$AM = \sqrt{1 + \left(\frac{s}{h}\right)^2}$$

物体及投影-空气质量计算器

Object & It's Shadow - Air Mass Calculator

输入物体的高度

Enter the object height, h = 1 units

Enter the shadow length, s = 1 units

输入影子的高度

大气质量

Air Mass, AM = 1.4142 units

The above calculation for air mass assumes that the atmosphere is a flat horizontal layer, but because of the curvature of the atmosphere, the air mass is not quite equal to the atmospheric path length when the sun is close to the horizon. At sunrise, the angle of the sun from the vertical position is 90° and the air mass is infinite, whereas the path length clearly is not. An equation which incorporates the curvature of the earth is[1]:

$$AM = \frac{1}{\cos(\theta) + 0.50572(96.07995 - \theta)^{-1.6364}}$$

以上有关空气质量的计算的前提是大气层是一个平面。然而，由于实际的大气层是弯曲的，当太阳接近地平线时，空气质量并不完全等同于光线穿过的大气层的路程。日出时，太阳位置与垂直方向的夹角为 90 度，计算所得空气质量为无穷大，但显然路程不是无穷大的。下面的公式在计算空气质量时考虑了地球的曲率 [1]：

$$AM = \frac{1}{\cos(\theta) + 0.50572(96.07995 - \theta)^{-1.6364}}$$

Standardised Solar Spectrum and Solar Irradiation

标准化的太阳光谱和太阳辐射

The efficiency of a solar cell is sensitive to variations in both the power and the spectrum of the incident light. To facilitate an accurate comparison between solar cells measured at different times and locations, a standard spectrum and power density has been defined for both radiation outside the Earth's atmosphere and at the Earth's surface.

太阳能电池的效率对于入射太阳光的功率及光谱变化都很敏感。为了准确在比较不同时间和不同地点测试的太阳能电池，我们定义了地球大气层外和地球表面的太阳辐射的光谱和功率密度的标准值。

The standard spectrum at the Earth's surface is called AM1.5G, (the G stands for global and includes both direct and diffuse radiation) or AM1.5D (which includes direct radiation only). The intensity of AM1.5D radiation can be approximated by reducing the AM0 spectrum by 28% (18% due to absorption and 10% to scattering). The global spectrum is 10% higher than the direct spectrum. These calculations give approximately 970 W/m^2 for AM1.5G. However, the standard AM1.5G spectrum has been normalized to give 1 kW/m^2 due to the convenience of the round number and the fact that there are inherently variations in incident solar radiation. The standard spectrum is listed in the Appendix page.

地球表面的标准光谱称为 AM1.5G（字母 G 表示总的辐射，包括直射和漫射分量）或者 AM1.5D（只包含了直射分量）。AM1.5D 的辐射强度可以通过将 AM0 的光谱强度减少 28%来估算（其中 18%是因为吸收，10%是因为散射）。总的光谱强度比直射光谱强度高 10%。通过以上计算，我们可以得到 AM1.5G 的功率密度约为970 W/m^2。然而，由于整数计算比较方便而且入射的太阳辐射本身就有浮动，我们规定标准的 AM1.5G 的光谱强度为1 kW/m^2。标准光谱在“附录”页面中给出。

The standard spectrum outside the Earth's atmosphere is called AM0, because at no stage does the light pass through the atmosphere. This spectrum is typically used to predict the expected performance of cells in space.

因为光没有穿过大气层，地球大气层外的标准光谱被称为 AM0。AM0 通常用于预测太空中的太阳能电池的工作情况。

原文地址：http://pvcdrom.org/pvcdrom/properties-of-sunlight/air-mass
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Intensity Calculations Based on the Air Mass

基于空气质量的强度计算

The intensity of the direct component of sunlight throughout each day can be determined as a function of air mass from the experimentally determined equation[2]:

$$I_D = 1.353 \cdot 0.7^{(AM^{0.678})}$$

where I_D is the intensity on a plane perpendicular to the sun's rays in units of kW/m^2 and AM is the air mass. The value of $1.353\ kW/m^2$ is the solar constant and the number 0.7 arises from the fact that about 70% of the radiation incident on the atmosphere is transmitted to the Earth. The extra power term of 0.678 is an empirical fit to the observed data and takes into account the non-uniformities in the atmospheric layers.

一天中阳光直射的强度可以通过空气质量来计算，以下是通过实验得到的公式[2]：

$$I_D = 1.353 \cdot 0.7^{(AM^{0.678})}$$

公式中，I_D为与光线方向垂直的平面上接收到的太阳光强度，单位为千瓦每平方米，AM 为空气质量。1.353 千瓦每平方米是太阳常数，0.7 则源于入射到大气层的辐射中大约有 70%可以到达地球表面这一事实。指数 0.678 是在考虑了大气层的不均匀性的情况下，通过对观测数据进行经验拟合得到的。

Sunlight intensity increases with the height above sea level. The spectral content of sunlight also changes making the sky 'bluer' on high mountains. Much of the southwest of the United States is two kilometers above sea level, adding significantly to solar isolation. A simple empirical fit to observed data[3] and accurate to a few kilometers above sea level is given by:

$$I_D = 1.353 \cdot \left[(1 - ah) \cdot 0.7^{(AM^{0.678})} + ah\right]$$

where a = 0.14 and h is the location height above sea level in kilometers.

随着海拔的上升，太阳光的强度也会上升，其光谱成分也会发生变化。因此，高山上的天空会更蓝。美国的西南部大部分地区海拔均超过 2000 米，因此这些地区的日照很强。对于观测数据进行简单经验拟合可以得到以下公式，它对于海拔几千米的位置的太阳辐射强度的计算都是准确的。

$$I_D = 1.353 \cdot \left[(1 - ah) \cdot 0.7^{(AM^{0.678})} + ah\right]$$

公式中，常数a等于0.14，h为某一位置的海拔高度，单位为千米。

Even on a clear day, the diffuse radiation is still about 10% of the direct component. Thus on a clear day the global irradiance on a module perpendicular to the sun's rays is:

$$I_G = 1.1 \times I_D$$

即使是在天气晴朗的时候，太阳辐射中的漫射分量仍然占到了直射分量的 10%左右。因此，天气晴朗的时候，与光线方向垂直的太阳能电池板接收到的总辐射量为：

$$I_G = 1.1 \times I_D$$

空气质量-辐射强度计算器

Air Mass - Radiation Intensity Calculator

空气质量
Air Mass, AM = 1.5 units

直射光线强度
Direct beam intensity, I_D = 0.846 kW/m^2
Estimate of global irradiance, I_G = 0.9306 kW/m^2
总照度的估计值

参考文献

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