Fundamental Physics for Electronics I
Quantum Physics

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Chapter 1

Waves and Particles

1.1 Particle Nature of Light I

Intensity spectrum observation of light emitted from a furnace suggests the quantization of the light energy by hf (Planck's quantum hypothsis).

$$\langle E \rangle = kT \qquad \text{(Classical theory)}$$

$$\langle E \rangle = \frac{kT}{1 - \exp(hf/kT)} \qquad \text{(Observation)}$$

1.2 Particle Nature of Light II

While some amount of energy ϕ is needed for the electron emissions on the metal surface, light is able to give out such energy needed for the emission, however, the observation shows that the energy depends soley on the frequency given by $E = hf$, and it has little to do with the intensity of the light (Einstein's photon hypothesis).

1.3 Particle Nature of Light III

Any kind of light detectors including a photo-film can detect a very weak light as a particle.

A very weak light can never expose a photo-film constantly, but makes random dot images with almost the same size.

1.4 Light Behaves as Waves or as Particles

Light is observed in particles when an interference experiment is carried out by a very weak light, yet a collection of particle images remains the same as the interference pattern used by a strong light.

Particles are seldom found in the areas in which the strong light vanishes in the interference, but instead they are found in the areas where the strong light strengthens each other with interference.

The conclusion is that the particles are observed in the probability, which is proportion to the intensity calculated under the wave assumption.

1.5 Wave-Particle Duality for Other Materials

In classic mechanics, electrons, protons and neutrons are belived to exhibit only the property of particles. However, these particles too can be made interfere and thus appear wave-like: electron diffraction, neutron diffraction, etc.

Quantum mechanics empasises that every material and phenomena is determined by a probalistic process, where there exist the interference phenomenon observed along.

1.6 Einstein and De-Broglie relations

The energy with particle-like porperty is proportional to the frequency, and the momentum is proportional to the wave number.

When angular frequency is ω, and the angular wave number is k, Einstein relation and De-Broglie relation are expressed as follows:

$$E = \hbar\omega \qquad \text{(Einstein Relation)}$$

$$p = \hbar k \qquad \text{(De-Broglie Relation)}$$

$$\text{where} \qquad \hbar = h/2\pi = 1.0546 \times 10^{-34}\text{Js}.$$