The Art of Electric Fields and Fluorescent Tubes

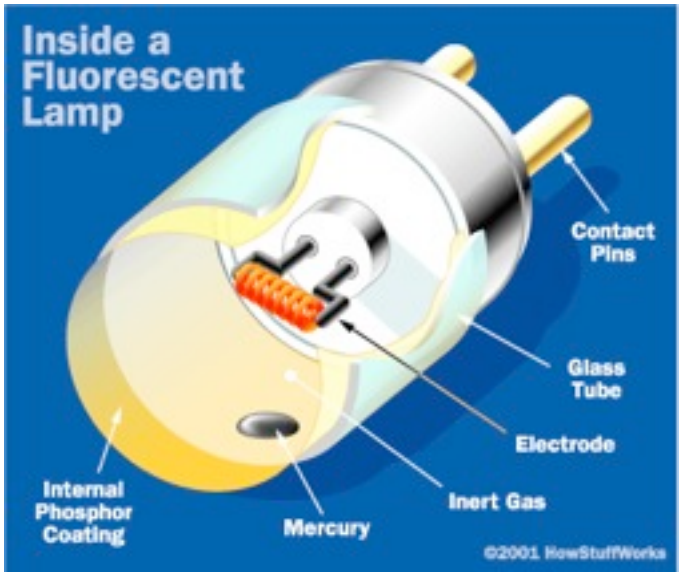
In 2004, Richard Box, artist-in-residence at Bristol University's physics department create the above-pictured art installation. His piece consists of 1301 fluorescent tubes placed over 3600 square meters below high-voltage power lines.

Box says that he was inspired to create the installation because of “the amazement of taking something that’s invisible and making it visible.”

Why do the 1301 fluorescent tubes glow when simply placed in the ground beneath the power lines?

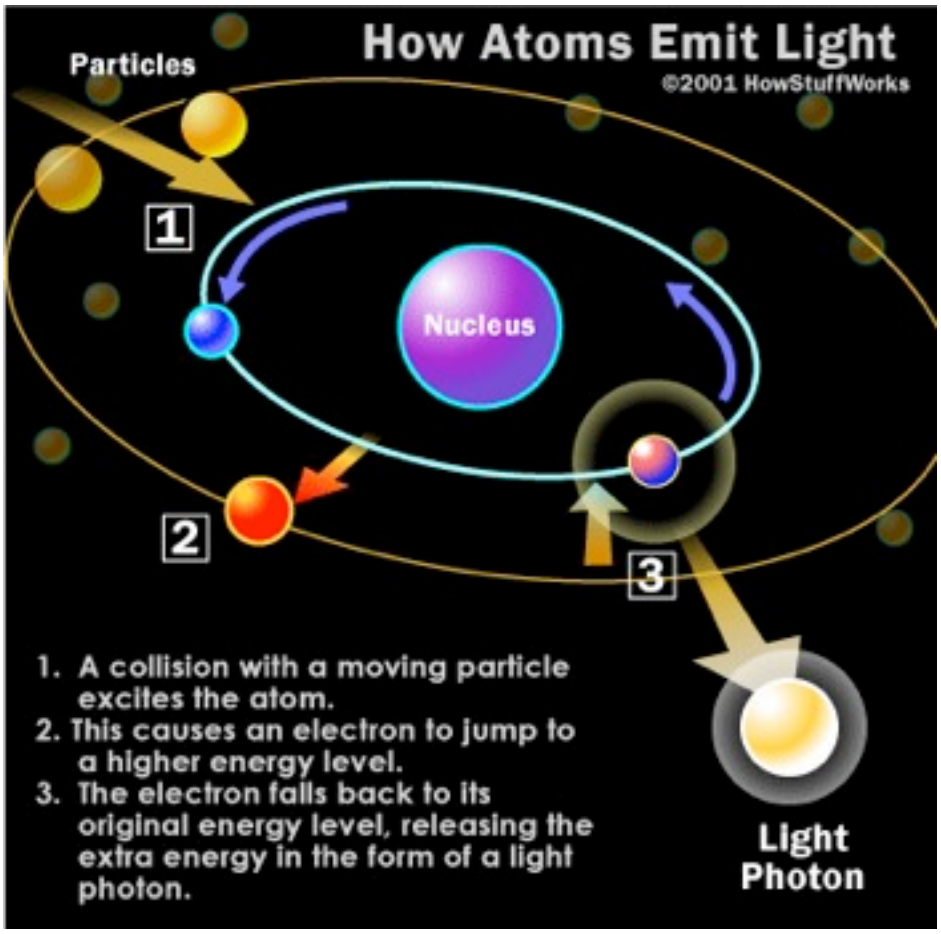
The invisible source of the energy for the 1301 fluorescent tubes is the electric field between the high-voltage power lines and the Earth. These high-voltage power lines have a voltage (electric pressure) of 400,000 V relative to the ground. This voltage creates an electric field between the power lines and the ground. Between any two vertical points in that region, there is a voltage. Between the top of the fluorescent tube and the ground, there is a sufficient voltage to illuminate the tube as if it were plugged into a socket.

The voltage applied to the fluorescent tubes does not simply produce a current through a resistive filament that then glows as the power is dissipated as it does in an incandescent bulb. The physics that produces visible light in a fluorescent tube is much more interesting.

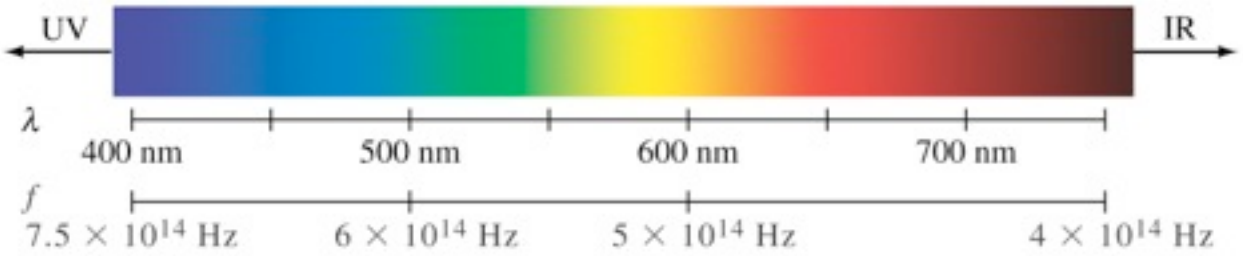


The voltage is applied to the fluorescent tube and, more specifically, the cathode in the tube, the cathode is heated and, when sufficient voltage is applied, emits electrons

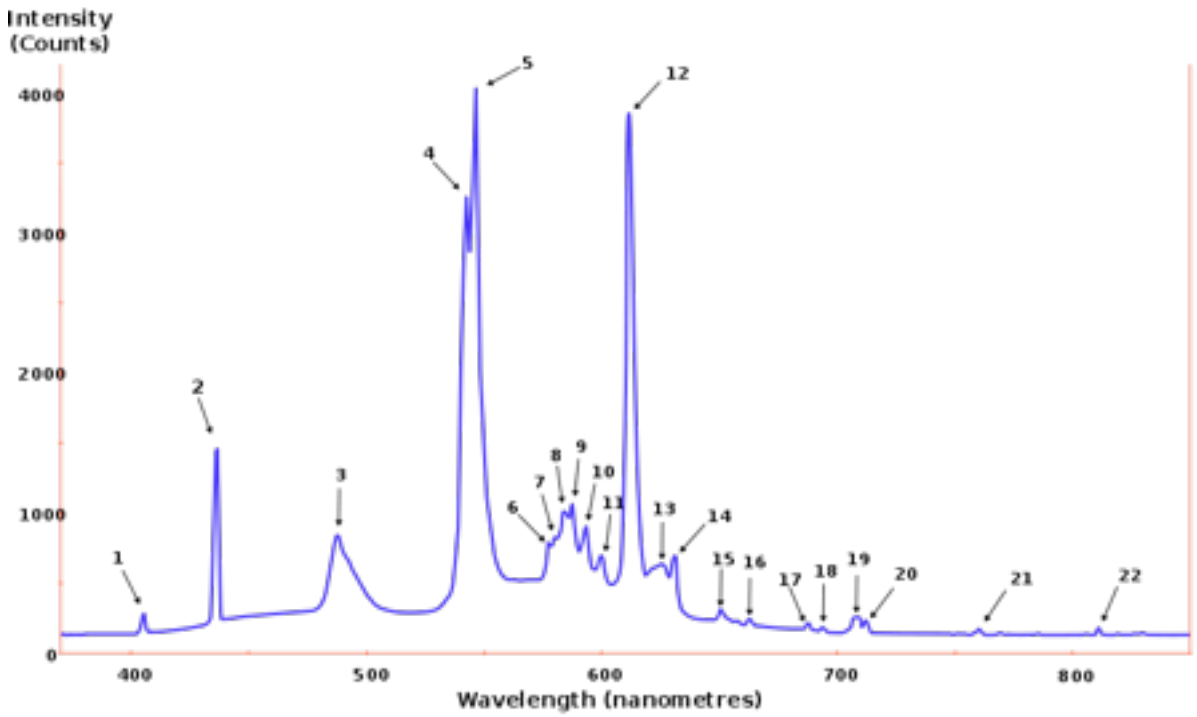
into the tube. These emitted electrons have a great deal of kinetic energy. The fluorescent tubes are filled with a combination of mercury vapor and one of the noble gases, such as argon. The pressure inside of a fluorescent tube is less than 1% of atmospheric pressure. Some of these high-energy electrons collide with atoms of the gas inside of the tube. If the electrons have sufficient energy when they collide with an atom of the gas, they can transfer some of their energy to excite an electron to a higher energy level. After a very short period of time, these excited electrons will "fall back" to their original energy levels and, in the process, emit a photon, a particle of light.



However, the story doesn't end here. These emitted photons from the mercury gas have a great of energy. The greater the energy of a photon, the higher the frequency. These photons are not in the visible spectrum but are in the ultraviolet part of the spectrum and, therefore, invisible to human eyes. We now get to the reason why fluorescent tubes are called "fluorescent." The inside of the tube is coated with a fluorescent material. When one of the ultraviolet photons collide with the fluorescent material on the inside of the tube, some of the energy is transferred to the electrons in the fluorescent material, elevating them to a higher energy level. The rest of the energy is absorbed by the fluorescent material. The fluorescent material is chosen such that the energy absorbed by the electron in that material is such that when that electron "falls back" to its original energy level, it emits a lower energy photon, a photon in the visible part of the spectrum. The fluorescent material may be a combination of different elements and compounds such that a variety of photons of different wavelengths in the visible spectrum are emitted.



This combination of photons of different wavelengths, where each wavelength is different color in the visible spectrum, are combined to form “white” light.



This installation would not have been possible with older designs of fluorescent tubes. Older designs required that the filaments be preheated before the tube would light. This preheating would ionize the mercury atoms in the fluorescent tube.

While Box claims not to be making a statement regarding the potential danger or high-voltage power lines, one cannot help to question the effect of electric fields of this strength on people and the effect of fluorescent tubes on both the environment and people.

Fluorescent tube contain a small amount of mercury which, when the fluorescent tube is at the end of its life, is deposited on the inside of the glass tube. Broken fluorescent tubes should be carefully deposed of in accordance with the EPA recommendations. Even if properly disposed of, this mercury eventually finds it way into our landfills.

In addition to the mercury concerns, fluorescent tubes emit some ultraviolet radiation due to those high-energy photons emitted from the Mercury atoms that don't interact with the fluorescent materials on the inside of the tube. While the amount of radiation received over an eight-hour period is only the equivalent of one minute of sun exposure. However, very sensitive people may react to this radiation.

A final concern, which this art installation raises, is the effect of high-voltage electric fields on the surrounding community. Since high-voltage lines are not the most attractive, nearby land is usually less expensive and, therefore, often used for parks and schools. There continues to be ongoing controversy over the effect of high-voltage lines on health. While the consensus appears to be that these high-voltage lines are safe, skeptics remain unconvinced.

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