Invited Oral Presentation (O)

UPDATE ON FIELD ELECTRON EMISSION SCIENCE AND TECHNOLOGY, 2026

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ABSTRACT

This Presentation aims to give a high-level overview of the present state of both technological and scientific work on field electron emission (FE).

Hoped for technological developments include: improved needle-type electron sources, in particular for electron beam instruments such as electron microscopes, improved large area electron sources, particularly those involving carbon based emitters, and new forms of "small flat transistors", based on "ballistic" electron travel in vacuum or air.

Work on the basic theory of FE continues slowly, with a large current emphasis on tidying up various basic aspects of the theory and reducing various types of entrenched error and weak practice, but also an emphasis on developing theory for "sharply curved" and "nanoscopic" emitters. There seems an urgent need for further significant theoretical development, in particular further improved theory relating to sharply curved emitters (and to related data-analysis procedures) and to "getting atoms into the theory".

FE theory continues to play a role in discussion of the origin of electrical breakdown in vacuum, with an interesting related development being observation of the growth of carbon nanowhiskers.

In the last 100 years there has only been one experiment that has been able to make a more-or-less reliable comparison between FE experiment and theory. A second method of doing this has recently been suggested and will be briefly described. Both experimental methods confirm that 1950s Murphy-Good FE theory is better than 1920s type FE theory (which is still often used).

More sophisticated theoretical developments involve the application of density-functional-theory to FE, other advanced computational techniques, and the development of a "digital twin" approach to real-time data analysis.

At a more fundamental level, there seem to be deep quantum-mechanical issues associated with some aspects of field electron emission, for example the origin of the "arrow of time", and the question of how the field electron (emission) microscope actually works, given that nowadays we can "see" electron bonds in the apex of a carbon nanotube.

Adjacent to FE there are other significant tasks under way, including improvement of aspects of the theory of electrostatics of pointed objects (including the so-called "classical lighting-rod effect)", and the question of whether the definition of voltage in the relevant International Standard actually does correspond to the quantity that engineers measure with a digital voltmeter.

Relevant references will be included in the written-up version of this presentation.