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30 Years of History and Future Perspectives of Superconducting Electronics

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From early on, Superconductive Electronics was in the mind of people looking to extend the boundaries of sensitivity, speed and energy efficiency. In Large Scale Applications, Kamerlingh Onnes very early on thought of creating high magnetic fields in a permanent current configuration. For Superconductive Electronics, it took a little longer to use the advantages of superconductivity: first digital devices – the Cryotrons - were developed in 1955 by Buck. With the invention of Josephson junctions in 1962, the age of the modern Superconductive Electronics began: within a short time, microwave effects like the Shapiro steps were found and the combination of Josephson effect and flux quantization led to the invention of rf- and dc SQUIDs and their application as highly-sensitivity magnetic field sensors, e.g. for detecting brain and heart magnetic signals. Applications in digital electronics followed: the famous IBM superconducting computer project and projects in Japan opened the field. Transition edge bolometers and tunnel junction detectors are very successful as sensitive detectors over a very wide frequency range - the list of device applications is too long to be fully covered in this talk.

The industrial side of Superconducting Electronics is a mixture of success and failure: the rise of the IBM Josephson computer project was a big stimulation for research on Superconductive Electronics, it's fall on the other side was a big blow to the community and only the steady excellent work of research groups like the groups in Japan kept digital SE alive. New ideas came up like RSFQ of the group around Likharev and stimulated new research and new enthusiasm in the field. With the need for very high energy efficiency and with superconducting quantum computing, it seems that digital superconducting electronics has finally found its niche to successfully compete with semiconductor electronics.

The situation for the commercial superconducting sensor market is similar: superconducting sensors are very successful in science, e.g. in astronomy, but gained only slowly access to the industrial markets. But in the last decade, applications in detecting minerals were very successful and the application for ECG in hospitals (demonstrated e.g. in Tsukuba and Osaka) finally seems to get ground.

Seen the long time, superconductivity and superconductive electronics is around, and seen the excellent results achieved internationally – well supported by the availability of smaller and high-reliability cooling techniques - it is highly likely that wider applications of this technique in our societies will take place.

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