Fundamental and Applied Metrology Based on Photonics

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It is not frequently noted, but nonetheless true, that our modern technological society is deeply dependent upon precision measurement: it is this capability that has delivered us a deep understanding of the properties of nature as well as exceedingly precise control of those properties. The most accurate and precise measurements have typically been based around photonic techniques. In these lectures I will introduce you to the concepts of precision measurement together with its constant companion: noise. We will then turn to why precise measurement is so frequently based on a measurement of time or frequency, and from there we will consider both some old and new methods for time-keeping and frequency measurement (all based on photonic methods). In particular, we will look at new types of frequency standards based on hollow-core photonic crystal fibres and micro-resonators. In the later lectures we will turn our attention to other sorts of measurements that one can make using photonics: magnetic field intensity, temperature, gravity, energy and length. Throughout the lectures I will attempt to illustrate with both practical and fundamental examples why these types of measurements are useful. We will also address the ultimate limitations to the performance of such devices.