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Proton Irradiation Response of a Radiation-Hard Femtosecond Fibre Bragg Grating

Reliable temperature sensing in intense radiation fields remains an important instrumentation challenge across high-energy physics (HEP), accelerator facilities and nuclear systems. In these environments, radiation may not only produce an instantaneous perturbation to an optical sensor, but also alter its underlying calibration and therefore its ability to provide reliable measurements after prolonged exposure. This work investigates both effects through the in-situ proton irradiation and pre- and post-irradiation characterisation of a radiation-hard femtosecond-written iXblue fibre Bragg grating (FBG).

Prior to irradiation, the FBG underwent controlled temperature calibration to establish its initial wavelength-temperature relationship and spectral characteristics. The sensor was subsequently exposed to the 24 GeV/c proton beam at the CERN Proton Synchrotron IRRAD facility, while its reflected spectrum was continuously interrogated throughout the irradiation. This enabled the evolution of the Bragg wavelength and spectral characteristics to be followed directly as radiation exposure accumulated, providing insight into the dynamic response of the grating under beam rather than relying exclusively on measurements performed before and after exposure.

Following irradiation, the temperature calibration was repeated under comparable conditions. Comparison of the pre- and post-irradiation response was used to distinguish radiation-induced offsets and spectral modifications from changes in temperature sensitivity. This distinction is particularly important for practical radiation instrumentation: an accumulated wavelength offset may potentially be corrected through recalibration, whereas a significant change in sensitivity or degradation of the grating response directly affects its suitability as a quantitative sensor.

The combination of real-time irradiation measurements with post-exposure metrological verification provides a framework for assessing whether femtosecond FBGs can remain functional sensing elements after high-dose particle exposure. Although performed using high-energy protons relevant to accelerator and particle-detector environments, the methodology has broader relevance to radiation-tolerant temperature and structural monitoring in nuclear facilities, irradiation beamlines and other extreme radiation environments. The results contribute towards the development and qualification of fibre-optic instrumentation capable of providing remote, multiplexed sensing where conventional electrical sensors may be constrained by radiation exposure, electromagnetic interference or accessibility.

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