On the question of the existence of needle radiation.
The 100 years old experiment on wide-angle interference
by Pál Selényi and the modern concept of photons

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Abstract. An overview on the concepts of needle radiation and of wide-angle interference experiments is given. The fundamental significance of Selényi’s experiment (1911) and its relevance in recent research are emphasized. Earlier and recent theories on localized configurations of radiation (e.g. ‘photon wave functions’) are discussed.

According to the concept of needle radiation, as introduced by J. J. Thomson in his Silliman lectures of 1903, in the elementary process of light emission, the radiations from a source are not distributed equally in azimuths, but are concentrated in certain directions. In 1905 A. Einstein introduced his point-like “Lichtquanten” (‘light quanta’ or ‘photons’) with the assumption that, “by spreading from a point, in the outgoing light rays the energy is not distributed continuously to larger and larger spatial regions, but these rays consist of a finite number of energy quanta localized in spatial points, which move without falling apart, and they can be absorbed or created only as a whole”. These two concepts are clearly different, and, moreover, both of them contradict to the experimental results found by Selényi [1] in 1911. The significance of Selényi’s classic wide-angle interference experiment has often been emphasized by Kossel [2], who considered it as an optical analogon and the first precursor of the observation of fine structure in x-ray interference in crystals (see Fig.1). One may safely state that Selényi’s result gave the first experimental evidence for the coherent elementary emission of ‘spherical photons’, according to modern quantumelectrodynamics.

Figure 1. Left: Sketch showing the analogy between the formation of Kossel lines in x-ray interferometry [2] and in Selényi’s experiment [1]. In the latter one a thin fluorescent dye layer (thickness less then 100nm) was put between a plate and a prism. The elementary radiation is coherent over $2\pi$ (note that this coherence is washed out with a thick layer). Selényi observed interference up to 100 degrees angle differences between ‘rays’. Center: shows one fringe pattern stemming from an outer source of radiation. The components of the secondary wave are coherent only between each other (they are stemming from the same incoming ray). The lattice fixes definite phase relations, but the initial phase drops out. Right: The primary source in the layer emits spherical waves, and the constructive or destructive interferences with the secondary waves result in the fine structure of fringes.

References