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Integration of the Two-Dimensional Power Spectral Density into Specifications for the X-ray Domain—Problems and Opportunities

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An implementation of the two-dimensional statistical scattering theory of Church and Takacs for the prediction of scattering from x-ray mirrors is presented with a graphical user interface. The process of this development has clarified several problems which are of significant interest to the synchrotron community. These problems have been addressed to some extent, for example, for large astronomical telescopes, and at the National Ignition Facility for normal incidence optics, but not in the synchrotron community for grazing incidence optics. Since it is based on the Power Spectral Density (PSD) to provide a description of the deviations from ideal shape of the surface, accurate prediction of the scattering requires an accurate estimation of the PSD. Specifically, the spatial frequency range of measurement must be the correct one for the geometry of use of the optic—including grazing incidence and coherence effects, and the modifications to the PSD of the Optical Transfer Functions (OTF) of the measuring instruments must be removed. A solution for removal of OTF effects has been presented previously, the Binary Pseudo-Random Grating. Typically, the frequency range of a single instrument does not cover the range of interest, requiring the stitching together of PSD estimations. This combination generates its own set of difficulties in two dimensions. Fitting smooth functions to two dimensional PSDs, particularly in the case of spatial non-isotropy of the surface, which is often the case for optics in synchrotron beam lines, can be difficult. The convenient, and physically accurate fractal for one dimension does not readily transfer to two dimensions. Finally, a completely statistical description of scattering must be integrated with a deterministic low spatial frequency component in order to completely model the intensity near the image. An outline for approaching these problems, and our proposed experimental program is given.

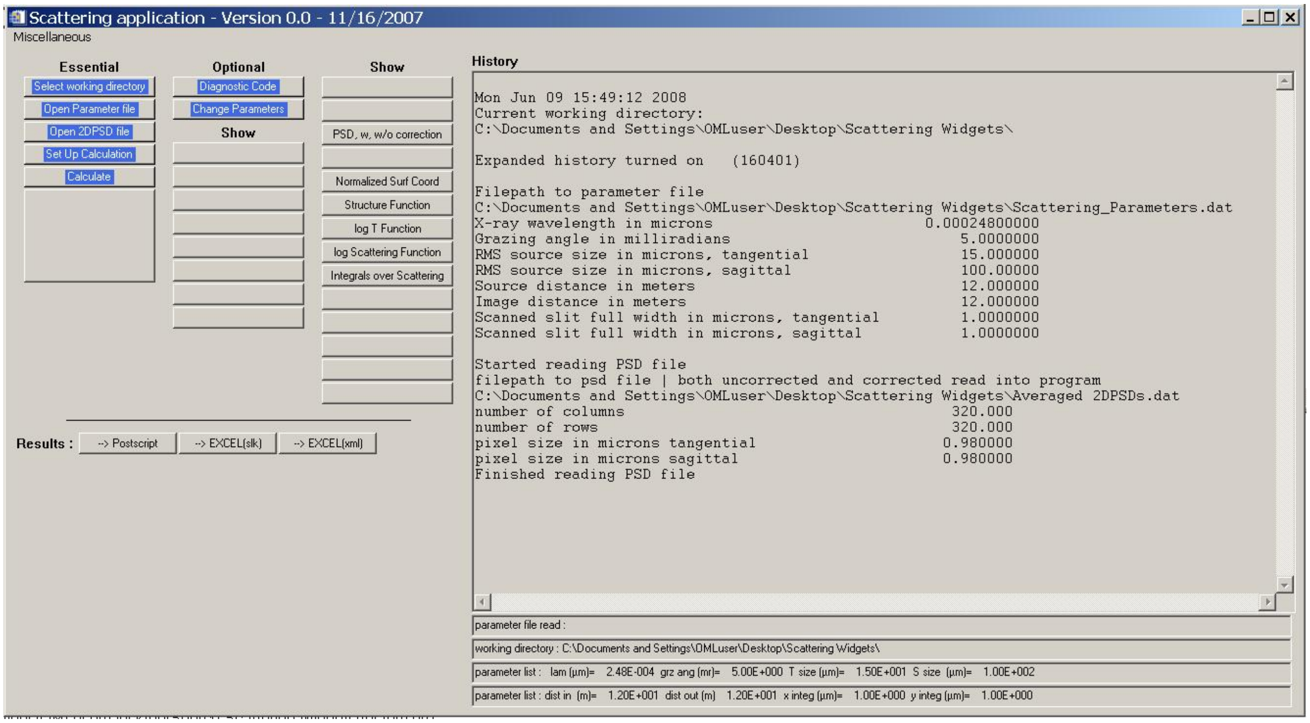

Figure 1. Graphical Interface for the Scattering Program

1. "Specification of surface figure and finish in terms of system performance," Church E. L., and Takacs, P. Z., Applied Optics, Vol. 32, Issue 19, pp. 3344-3353.

2. "Surface roughness of stainless-steel mirrors for focusing soft x rays," Yashchuk, Valeriy V., Gullikson, Eric M., Howells, Malcolm R., Irick Steve C., MacDowell, Alastair A., McKinney, Wayne R., Salmassi, Farhad, Warwick, Tony, Metz James P., and Tonnessen Thomas W.
Applied Optics, Vol. 45, Issue 20, pp. 4833-4842

3. "Binary pseudo-random grating as a standard test surface for measurement of modulation transfer function of interferometric microscopes," Yashchuk Valeriy V., McKinney Wayne R., and Takacs Peter Z., Optical Engineering, July 2008, in press.

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