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At the limit of source brilliance: Advanced Nondispersive Focusing Optics For Thermal Neutrons

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Kirkpatrick-Baez neutron super mirrors can efficiently focus neutron beams into small areas with a maximum divergence that is limited by the mirror critical angle. The size of the focal spot is primarily determined by geometrical demagnification of the source and by figure errors in the mirror shape. Ray tracing calculations show that high-performance Kirkpatrick-Baez supermirrors can preserve neutron-source brilliance when focusing down to tens of microns and can focus $\sim$ two orders of magnitude greater power into 100 μm than is practical without focusing. The predicted performance is near the theoretical limit set by the source brilliance. We describe the phase space arguments, ray tracing calculations and actual performance of an M3 supermirror system designed to produce a focal spot below 100 μm. Initial experiments with small polychromatic beams are also described. Although the current design is optimized for neutron polychromatic microdiffraction, the design principles are widely applicable to a range of neutron science.