The spectral transmission of the high-temperature gadolinium plasma created by the irradiation of the Z-pinch at the Angara-5-1 facility [[1]](#footnote-1)\*)

DOI: 10.34854/ICPAF.2023.50.2023.1.1.112

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Experiments on the creation of a high-temperature gadolinium plasma and the study of its spectral properties were carried out on the Angara-5-1 facility with a discharge current of up to 4 MA. During the implosion of tungsten multiwire arrays, a Z-pinch is formed, which is a source of a soft X-ray pulse with a power of up to 10 TW and a duration of ~8 ns. This ensures a power density of up to 1 TW/cm2 and an energy density of up to 10 kJ/cm2 on the target surface [1], which consisted of a Mylar film 0.6 μm thick with a deposited gadolinium layer 40 to 80 nm thick. The thickness of the Gd layer was controlled by atomic force microscopy. The measurement scheme made it possible to determine the spectral dependence of the transmission coefficient of the target plasma with a time resolution [2]. Numerical simulation of target irradiation by a Z-pinch was carried out using the two-dimensional radiative gas-dynamic code RALEF-2D [3]. This code implements the equations of hydrodynamics taking into account thermal conductivity and spectral transfer of thermal radiation. The radiation transfer is considered at each moment of time within the framework of the stationary transfer equation with those calculated in advance using the THERMOS code [4]. The FEOS model [5] is used to describe the equations of state in the RALEF-2D code. Mylar properties were described as follows. The photon ranges corresponded to the C5O2 mixture. The equation of state was taken as for pure carbon with modification of the parameters at low temperatures so that the density under normal conditions was 1.39 g/cm3 and the critical temperature was 640 K. The heating radiation in the calculations was approximated by the sum of three components with different spectra and time profiles, taking into account relatively weak but long prepulse [2] to be as close as possible to the experimental SXR pulse. Calculations show that on the frontal side of the target at the moment of SXR maxima the Gd plasma temperature is ~40-45 eV, density is ~0.5-1 mg/cm3. As in the case of other materials studied earlier [2], it was found in the experiment that the plasma transmission of the Gd+Mylar target near the maximum of the irradiation pulse increases many times over in comparison with the transmission of the "cold" target material in the wavelength range ~50-200 Å. Also, in the high-temperature plasma of the target, a narrow absorption band is observed in the region of ~65-70 Å. This work was supported by the Russian Foundation for Basic Research (grant No. 20-21-00082) and PI "Science and Innovation".

References

1. V.V. Aleksandrov, et al., Plasma Physics Reports, 2021, Vol. 47, No. 7, pp. 669–703.
2. V.V. Aleksandrov, et al., Plasma Physics Reports, 2022, Vol. 48, No. 9, pp. 983–1004.
3. M.M. Basko, J. Maruhn, and A. Tauschwitz, J. Comput. Phys. 2009 228, 2175.
4. A.F. Nikiforov, et al., Quantum-Statistical Models of Hot Dense Matter. Methods for Computation Opacity and Equation of State (Birkhauser, Basel, Switzerland 2005).
5. S. Faik, M.M. Basko, et al., High Energy Density Physics 2012 8, 349.

1. \*) [abstracts of this report in Russian](http://www.fpl.gpi.ru/Zvenigorod/L/It/ru/DI-Gritsuk.docx) [↑](#footnote-ref-1)