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## N = 4 supersymmetric Yang-Mills thermodynamics to order $\lambda^2$

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We calculate the resummed perturbative free energy of calN = 4 supersymmetric Yang-Mills in four spacetime dimensions through second order in the 't Hooft coupling  $\lambda$  at finite temperature and zero chemical potential. Our final result is ultraviolet finite and all infrared divergences generated at three-loop level are canceled by summing over calN = 4 supersymmetric Yang-Mills ring diagrams. Non-analytic terms at  $calO(\lambda^{3/2})$ and  $calO(\lambda^2 \log \lambda)$  are generated by dressing the  $A_0$  and scalar propagators. The gauge-field Debye mass  $m_D$ and the scalar thermal mass  $M_D$  are determined from their corresponding finite-temperature self-energies. Based on this, we obtain the three-loop thermodynamic functions of calN = 4 supersymmetric Yang-Mills to  $calO(\lambda^2)$ . We compare our final result with prior results obtained in the weak- and strong-coupling limits and construct a generalized Pad\'{e} approximant that interpolates between the weak-coupling result and the large- $N_c$  strong-coupling result. Our results suggest that the  $calO(\lambda^2)$  weak-coupling result for the scaled entropy density is a quantitatively reliable approximation to the scaled entropy density for  $0 \le \lambda \le 2$ . }

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