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Calculation of Superpropagators in Non-linear Quantum Field Theories

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Abstract. A new method of constructing the superpropagators, i.e. the Fourier transforms of the expressions of the form $\sum_{n=1}^{\infty} c_n \Delta_F^n(x)$ is suggested. The method makes it possible to derive by use of the same technique explicit analytic expressions for the superpropagators for a wide class of field theories – from strictly local up to essentially non-local. The essence of the method is the construction of a differential equation for the superpropagator which in general is of an infinite order. By use of the boundary condition at $p^2 = 0$ we find the solution of this equation depending on one arbitrary real parameter. Simple examples are given to illustrate the method.

I. Introduction

In the theories with the essentially nonlinear (non-polynomial) Lagrangians (for example, in the chiral field theories) one encounters the necessity of calculating the superpropagators, i.e. the Fourier transforms of the expressions of the form[1] $\sum_{n=1}^{\infty} c_n [g^2 \Delta_F(x)]^n$. The same problem holds for the polynomial nonrenormalizable field theories treated by use of equivalence theorems. In the present paper a rather general method of constructing the superpropagators is suggested. This method makes it possible to derive explicit analytic expressions for the superpropagators for a wide class of field theories – from strictly local up to essentially non-local – by use of the same technique.

The idea of the method originates in the earlier investigations of the approximate linear integral equations for the Green's functions in nonrenormalizable theories [1–6]. In particular, the Edwards equations, the Bethe-Salpeter equations and the integral equation for the simplest superpropagator which corresponds to the expression

$$\Delta_F(x)\,[1 - g^2 \Delta_F(x)]^{-1}$$

[1] The notations are introduced below.