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*Solution of  $f(A)x = b$  with Krylov  
subspace information*

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**11.1 Introduction**

In this chapter, I expand on an idea for exploiting Krylov subspace information obtained for the matrix  $A$  and the vector  $b$ . This subspace information can be used for the approximate solution of a linear system  $f(A)x = b$ , where  $f$  is some analytic function,  $A \in \mathbb{R}^{n \times n}$ , and  $b \in \mathbb{R}^n$ . I will make suggestions on how to use this for the case where  $f$  is the matrix *sign* function. The matrix *sign* function plays an important role in QCD computations, see for instance [147].

In [197] an approach was suggested for the use of a Krylov subspace for the computation of approximate solutions of linear systems

$$f(A)x = b.$$

The approach was motivated by the function  $f(A) = A^2$ , which plays a role in the solution of some biharmonic systems. The approach is easily generalized for nonsymmetric complex matrices, but we may have to pay more attention to the evaluation of  $f$  for the reduced system, associated with the Krylov subspace.

In particular, I will discuss some possible approaches in which the Krylov subspace is used for the computation of  $\text{sign}(A)p$  for given vectors  $p$ . With the evaluation of the matrix *sign* function we have to be extremely careful. A popular approach, based on a Newton iteration, converges fast, but is sensitive for rounding errors, especially when  $A$  is ill-conditioned. We will briefly discuss a computational method that was suggested (and analysed) by Bai and Demmel [15]. This approach can also be combined, in principle, with the subspace reduction technique.

# Iterative Krylov Methods For Large Linear Systems

**M Mark**



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