Abstract ID: P20

## LINEAR STABILITY ANALYSIS OF MORE GENERAL LINEAR ITERATION SCHEME IN THE IMPLEMENTATION OF IMPLICIT RUNGE KUTTA METHODS Abstract ID: P20<br>
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S. Kajantham<sup>a</sup>, R. Vigneswaran<sup>b</sup><br>
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ATION SCHEME IN THE IMPLEMENTATION OF**<br> **IMPLICIT RUNGE KUTTA METHODS**<br>
S. Kajanthan<sup>\*</sup>, R. Vigneswaran<sup>5</sup><br> *Department of Interdisciplinary Studies, Faculty of Technology,*<br> *D* **EXAMILITY ANALYSIS OF MORE GENERAL LINEAR**<br> **IABLEME IN THE IMPLIEMENTATION OF**<br> **IMPLICIT RUNGE KUTTA METHODS**<br>
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## Abstract

A more general linear iterative scheme solves non-linear equations arising in the implementation of implicit Runge-Kutta methods proposed by Cooper and Butcher is of the form

$$
\[I_s \otimes (I_n - h\lambda J)\]E^m = (BS^{-1} \otimes I_n)D(Y^{m-1}) + (L \otimes I_n)E^m,
$$
  

$$
Y^m = Y^{m-1} + (S \otimes I_n)E^m, \quad m = 1, 2, ...,
$$

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ME IN THE IMPLEMENTATION OF<br>
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Sajanthan<sup>\*</sup>, R. Vigneswaran<sup>b</sup><br>
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miversity of Jaffna, Sri Lanka.<br>
<br> *kajant* **IMPLICIT RUNGE KUTTA METHODS**<br>
S. Kajanthan<sup>a\*</sup>, R. Vigneswaran<sup>b</sup><br>
<sup>*a</sup>Department of Interdisciplinary Studies, Faculty of Technology,<br>
<i>University of Jaffha*, *Sri Lanka.*<br> *b*Department of Mathematics and Statistics, </sup> matrix of order s, and  $\lambda$  is a real constant. They showed that successive over relaxation technique applied to improve the convergence rate of this scheme. Later, convergence result of this scheme established by proving some theoretical results suitable for stiff problems. This article examines stability properties of this linear iterative scheme with the alternate approximation f Mathematics and Statistics, Faculty of Science,<br>
University of Jaffna, Sri Lanka.<br>
"kajanthans@univ.jfn.ac.lk<br> **Abstract**<br> **Abstract**<br> **Abstract**<br> **Abstract**<br> **Abstract**<br> **Abstract**<br> **Abstract**<br> **Abstract**<br> **Abstract**<br> \*Department of Mathematics and Statistics, Faculty of Science,<br>  $\Delta$  . The straight of Science,<br>  $\Delta$  . The straight answers of  $\Delta$  . The straight of  $\Delta$  . The straight of  $\Delta$  . Abstract<br>
A more general linear iterativ A more general linear iterative scheme solves non-linear equations arising in the<br>implementation of implicit Runge-Kutta methods proposed by Cooper and Butcher<br>is of the form<br> $\left[I_x \otimes (I_n - h\lambda J)\right]E^m = \left(BS^{-1} \otimes I_n\right)D\left(Y^{n+1$ non-linear equations arising in the<br>
ds proposed by Cooper and Butcher<br>  $((Y^{m-1})+(L\otimes I_n)E^m,$ <br>  $)E^m$ ,  $m=1,2,...$ ,<br>
es and L is strictly lower triangular<br>
They showed that successive over<br>
vergence rate of this scheme. Late ative scheme solves non-linear equations arising in the<br>
Runge-Kutta methods proposed by Cooper and Butcher<br>  $\iiint_{E''} E(BS^{-1} \otimes I_n)D(Y^{m-1}) + (L \otimes I_n)E^m$ ,<br>  $Y^m = Y^{m-1} + (S \otimes I_n)E^m$ ,  $m = 1, 2, ...,$ <br>
s non-singular matrices and L rative scheme solves non-linear equations arising in the<br>
Runge-Kutta methods proposed by Cooper and Butcher<br>  $\iiint_E^m = (BS^{-1} \otimes I_n)D(Y^{m-1}) + (L \otimes I_n)E^m$ ,<br>  $Y^m = Y^{m-1} + (S \otimes I_n)E^m$ ,  $m = 1, 2, ...,$ <br>
s non-singular matrices and L erative scheme solves non-linear equations arising in the<br>it Runge-Kutta methods proposed by Cooper and Butcher<br> $J$ ]  $E^m = (BS^{-1} \otimes I_n)D(Y^{m-1})+(L \otimes I_n)E^m$ ,<br> $Y^m = Y^{m-1}+(S \otimes I_n)E^m$ ,  $m = 1, 2, ...,$ <br>ex non-singular matrices and s non-linear equations arising in the<br>
ods proposed by Cooper and Butcher<br>  $D(Y^{m-1}) + (L \otimes I_n) E^m$ ,<br>  $m = 1, 2, ...,$ <br>
ces and *L* is strictly lower triangular<br>
They showed that successive over<br>
nvergence rate of this scheme. L  $e^x$  scheme solves non-linear equations arising in the<br>
mge-Kutta methods proposed by Cooper and Butcher<br>  $e^{r_m} = (BS^{-1} \otimes I_n)D(Y^{n-1}) + (L \otimes I_n)E^m$ ,<br>  $e^{r_m} = Y^{n-1} + (S \otimes I_n)E^m$ ,  $m = 1, 2, ...,$ <br>  $e^{r_m} = Y^{n-1} + (S \otimes I_n)E^m$ ,  $m =$ le form<br>  $\left[I_s \otimes (I_n - h\lambda J)\right] E^m = (BS^{-1} \otimes I_n)D(Y^{m-1}) + (L \otimes I_n)E^m$ ,<br>  $Y^m = Y^{m-1} + (S \otimes I_n)E^m$ ,  $m = 1, 2, ...,$ <br> *B* and *S* are real *s x s* non-singular matrices and *L* is strictly lower triangular<br>
of order *s*, and *λ*  $I_s \otimes (I_n - h\lambda J)$   $E^m = (BS^{-1} \otimes I_n)D(Y^{m-1}) + (L \otimes I_n)E^m$ ,<br>  $Y^m = Y^{m-1} + (S \otimes I_n)D(Y^{m-1}) + (L \otimes I_n)E^m$ ,<br>  $Y^m = Y^{m-1} + (S \otimes I_n)E^m$ ,  $m = 1, 2, ...,$ <br>
45 are real 5×5 non-singular matrices and *L* is strictly lower triangular<br>
and  $\$  $2^{n-2}$   $\rightarrow$   $\infty$   $\rightarrow$   $\infty$   $\infty$  $I_n |D(Y^m|^2) + (L \otimes I_n) E^m$ ,<br>  $S \otimes I_n |E^m$ ,  $m = 1, 2, ...,$ <br>
matrices and *L* is strictly lower triangular<br>
ant. They showed that successive over<br>
econvergence rate of this scheme. Later,<br>
shed by proving some theoretical result  $Y^m = Y^{m-1} + (S \otimes I_n) E^m$ ,  $m = 1, 2, ...,$ <br>
where *B* and *S* are real *s* × *s* non-singular matrices and *L* is strictly lower triangular<br>
matrix of order *s*, and  $\lambda$  is a real constant. They showed that successive over<br>
r  $Y^m = Y^{m-1} + (S \otimes I_n) F^m$ ,  $m = 1, 2, ...,$ <br>
orce *B* and *S* are real *s* × s non-singular matrices and *L* is strictly lower triangular<br>
trix of order *s*, and  $\lambda$  is a real constant. They showed that successive over<br>
axatio

$$
y_{n+1}^k = y_n + h\Big(b^T A^{-1} \otimes I\Big)\Big(Y^k - e \otimes y_n\Big) .
$$

stiff problem. For a fixed starting value  $Y^0 = e \otimes y_n$ , we obtain

$$
y_{n+1}^{k} = R(z)y_{n} + b^{T} A^{-1} M(z)^{k} \left(I - \frac{1}{z} A^{-1}\right)^{-1} e y_{n}
$$

here  $R(z) = 1 + zb^{T}(I - zA)^{-1}e$  is the stability function of the method and  $M(z) = (Q - zT)^{-1} [Q - I + z(A - T)]$  where  $Q = SB^{-1}(I - L)S^{-1}$  and  $T = \lambda SB^{-1}S^{-1}$ .<br>This shows that linear stability properties were preserved in the limit.

Keywords: iteration scheme, linear stability, implicit Runge Kutta methods