

# Implicit two-derivative Runge–Kutta collocation methods for systems of initial value problems

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## Abstract

We introduce a new class of implicit two-derivative Runge–Kutta collocation methods designed for the numerical solution of systems of equations and show how they have been implemented in an efficient parallel computing environment. We also discuss the difficulty associated with large systems and how, in this case, one must take advantage of the second derivative terms in the methods. We consider two modified versions of the methods which are suitable for solving stable systems. The first modification involves the introduction of collocation at the two end points of the integration interval in addition to the Gaussian interior collocation points and the second involves the introduction of a different class of basic second derivative methods. With these modifications, fewer function evaluations per step are achieved, resulting into methods that are cheap and easy to implement. The stability properties of these methods are investigated and numerical results are given for each of the modified version to illustrate the computational efficiency of the modified methods.

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**Keywords:** Block hybrid discrete scheme; Continuous scheme; System of equations; Two-derivative Runge–Kutta methods

## 1. Introduction

The primary aim of this paper is to introduce a new class of implicit two-derivative Runge–Kutta (TDRK) collocation methods for the numerical solution of initial value problems for systems of ordinary differential equations (ODEs),

$$\begin{cases} y'(x) = f(x, y(x)), & x \in [x_0, T], \\ y(0) = y(x_0). \end{cases} \quad (1)$$

Here  $y : [x_0, T] \rightarrow \mathbb{R}^d$  and  $f : [x_0, T] \times \mathbb{R}^d \rightarrow \mathbb{R}^d$  is assumed to be sufficiently smooth and  $y_0 \in \mathbb{R}^d$  is the given initial value. Let  $h > 0$  be a constant stepsize and define the grid by  $x_n = x_0 + nh$ ,  $n = 0, 1, 2, \dots, N$  where  $Nh = T - x_0$  and a set of equally spaced points on the integration interval is defined by  $x_0 < x_1 < x_2 < \dots < x_{n+1} = T$ .

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web uhusiano uliopo kati sintaksia na mofolojia besha 2007 49 anasema mofolojia ni taaluma inayojishughulisha na kuchambua muundo wa maneno katika lugha pia rubanza 1996 1 anasema mofolojia ni taaluma inayoshughulikia vipashio vya

**little caesars pizza online pizza siparişi** - Aug 17 2023

web little caesars türkiye ailesi olarak müşterilerimizin ve çalışanlarımızın sağlığını çok önemseriz detay türkiye de en büyük pizza markalarından biri olan little caesars ın kampanya ve fırsatları ile tanışmak ve sipariş vermek için bizimle tanışmaya başlayın

türkiye nin yerli pizza markası pizza lazza - Dec 09 2022

web birbirinden leziz pizzalar ekstra lezzetler tüm kampanyalar ve fırsatları keşfedin pizza lazza da hemen sipariş vermek için tıklayın

**pizza kampanyaları little caesars** - Feb 11 2023

web eşsiz pizza lezzetini tüm şubelerinde sunan little caesars ürünlerinde aradığınız lezzeti en uygun fırsatlar eşliğinde bulabilirsiniz 1 kişilik 1 2 kişilik 2 3 kişilik 3 4 kişilik ve 5 6 kişilik gibi pek çok farklı seçeneğe sahip olan kampanyalar pizzalar ve menüler herkes için farklı seçeneklerle yer alıyor

**pizza kampanyaları dominos pizza** - Jun 15 2023

web domino s tan avantajlı kampanyalar birbirinden lezzetli pizzaları avantajlı kampanyalarla sepetine doldurmak istersen doğru yerdesin favori dominos pizzanı seç ve siparişini ver

[pizza hut](#) - May 14 2023

web pizza hut

**tüm pizzalar domino s pizza** - Jul 16 2023

web 200 tl den başlayan fiyatlarla sipariş ver domino s pizza nın birbirinden lezzetli pizza çeşitleri 30 dakikada kapıda domino s dünyasının en iyi pizzaları ve pizza kampanyaları seni bekliyor

[Şımartan pizza Çeşitleri online pizza sipariş hattı pizza lazza](#) - Jan 10 2023

web aradığın şımartan pizzalar burada pizza lazza nın büyük orta ve küçük boy pizza seçenekleri ile benzersiz lezzetleri keşfetmek için hemen sipariş ver

**domino s pizza türkiye nin en sevilen pizza markası** - Sep 18 2023

web 0850 755 33 22 info dominospizza com tr her zevke hitap eden lezzetli pizzalar ekstra lezzetler dilediğin hamur ve kenar seçenekleri domino s pizza da Üstelik çok avantajlı kampanyalarla hemen tıkla 30 dakika da kapıda

[terra pizza](#) - Mar 12 2023

web terra pizza franchising restoranlarımız fırınlarımızı çalıştırmaya başladığımız her sabah en taze malzemeleri özenle seçiyor en yenilikçi tarifleri birbirine gel beraber olsun diyecek insanlar için hazırlıyoruz pizza kültürüne yenilik ve özgünlük katan terra pizza sana sevdiklerine ve herkese sesleniyor

[evde kolay resimli farklı pizza tarifleri nefis yemek tarifleri](#) - Apr 13 2023

web pizza tarifleri hazırlarını aratmayan lezzetli pizza hamuru tarifi ile başlayıp farklı malzemelerle zenginleştirdiğimiz her cebe uygun pizza tarifleri pizza sosu tarifi karışık pizza tarifi pratik şıpsak pizza çeşitleri porsiyonluk mini pizzalar ve birbirinden değişik pizza tarifleri videolu ve resimli anlatımlarıyla