# Extra and Alternative Loop Rings

#### K.Jayalakshmi¹and C.Manjula²

Assistant Professor in Mathematics, J.N.T.University Anantapur College of Engg., J.N.T.University Anantapur, Anantapur (A.P.) INDIA.
Department of Mathematics, J.N.T.University Anantapur College of Engg., J.N.T.University Anantapur, Anantapur (A.P.) INDIA.

Abstract—The right alternative law implies the left alternative law in loop rings of characteristic other than 2. We show that there exists a loop which fails to be an extra loop, even though its characteristic 2 loop rings are right alternative.

Index Terms - Alternative loop, extra loop, inverse property, alternative ring, alternative loop ring.

2010 MATHEMATICS SUBJECT CLASSIFICATION: 17D05, 17D15.

#### I. INTRODUCTION

Throughout this paper  $(L, \cdot)$  always denotes a loop, with identity element e and  $(R, +, \cdot)$  always denotes an nonassociative commutative ring, with identity element  $1 \neq 0$ . Then RL denotes the loop ring constructed from R and L. Elements of RL are represented by finite formal sums of the form  $\sum_{i \in n} a_i x_i$ , where the  $x_i$  are elements of L and the  $a_i$  are elements of R. The sum and product operations on RL are defined in the obvious way. Then 1e is the identity element of RL. For more details, background information, and references to the earlier literature see the survey by Goodaire and Milies [1]. We note that L is embedded in to RL via the map  $x \rightarrow 1x$ ; we usually write the element 1x simply as x. In this paper we would like to focus on right alternative law  $((x \ y)y = x(y \ y))$  and the left alternative law  $((y \ y)x = y(y \ x))$ . The right alternative law in RL is precisely more efficient over the right alternative law in L.

In the case that L is finite; Theorem 2 was proved by Chein and Goodaire [7]. Their proof relied on structure theorems of Bruck and Albert which are false for infinite L. Goodaire and Robinson [2 and 3] showed that the assumption in the theorem that R satisfies  $1 + 1 \neq 0$  cannot be dropped. Actually, in the study of alternative laws in loop rings RL, only L.

REMARK: RL is associative iff L is associative.

is relevant, by the following result from [7]:

THEOREM 1: A loop L is an RA loop if and only if L is not associative and has the following properties:
i) if three elements of L associative in some order, then they associate in all orders;
ii) if g, h, k ∈ L do not associate, then g ⋅ kh = gh ⋅ k = h ⋅ gk.

**PROOF**: First, suppose that L is an RA loop and R is some ring of characteristic different from 2. Since  $L \subseteq RL$  and RL is an alternative ring, statement (i) holds by the Generalized Theorem of Artin [5]. To obtain (ii) let g, h and k be three elements of L which do not associate and put x = h + k, y = g in the right alternative identity,  $yx \cdot x = yx^2$ . We obtain  $gh \cdot h + gh \cdot k + gk \cdot h + gk \cdot k = gh^2 + g \cdot hk + g \cdot kh + gk^2$  and since  $gh \cdot h = gh^2$  and  $gk \cdot k = gk^2$ ,  $gh \cdot k = gk^2$ .

 $gk \cdot h = g \cdot hk + g \cdot kh$ . Because char  $R \neq 2$ ,  $gh \cdot k$  is in the support of the left side and thus in the support of the right. So, if  $gh \cdot k \neq g \cdot hk$ , then  $gh \cdot k = g \cdot kh$ . Similarly, by considering the left alternative identity, we obtain  $gh \cdot k = h \cdot gk$ .

Conversely, suppose that L is a loop which satisfies statements (i) and (ii) of the theorem. Let R be a commutative and associative ring with unity. For  $x = \sum a_g g$  and  $y = \beta_g g$  in RL,  $yx \cdot x - yx^2$  is a linear combination of terms of the form  $gh \cdot k - g \cdot hk$ . If h = k, then  $gh \cdot h = g$ , hh by associativity or (ii), so  $yx \cdot x - yx^2$  reduces to a sum of terms of the form  $(gh \cdot k - g \cdot hk) + (gk \cdot h - g \cdot kh)$  with  $h \neq k$  and this is 0 by (i) and (ii). This shows that the right alternative identity holds in RL. The left alternative identity follows in a similar way.

COROLLARY 1: An RA loop is an extra loop.

**PROOF:** Let L be an RA loop. If x, y and z are three elements of L which associative, then, by Moufang's Theorem, these elements generate a group, so (xy - z)x = x(y - zx) is clear. If x, y and z do not associative, then neither do (xy - z)x = x(y - zx) is clear. If x, y and z do not associative, then neither do xy, z, x (again by Moufang's Theorem), so (xy - z)x = (x y)(x - z) by Theorem 1 and, since x, y, xz do not associate, (x y)(x - z) = x(xz - y). Repeated use of Theorem 1 gives  $xz \cdot y = z \cdot xy = zy \cdot x = y - zy$  and so, again (xy - z)x = x(y - zx).

We begin by eliminating the rings from the theory of loop rings. Lemma 1 almost does that, since it expresses right alternativity in RL just in terms of elements of the form 1x (which, recall, we are writing as x). The material through Lemma 2 is from Chein and Goodaire [7].

**LEMMA 1**: RL is right alternative iff L is right alternative and RL satisfies

# **Alternative Loop Rings**

Kossuth Lajos Tudományegyetem. Matematikai Intézet

#### **Alternative Loop Rings:**

Alternative Loop Rings E.G. Goodaire, E. Jespers, C. Polcino Milies, 1996-10-24 For the past ten years alternative loop rings have intrigued mathematicians from a wide cross section of modern algebra As a consequence the theory of alternative loop rings has grown tremendously. One of the main developments is the complete characterization of loops which have an alternative but not associative loop ring Furthermore there is a very close relationship between the algebraic structures of loop rings and of group rings over 2 groups Another major topic of research is the study of the unit loop of the integral loop ring Here the interaction between loop rings and group rings is of immense interest This is the first survey of the theory of alternative loop rings and related issues Due to the strong interaction between loop rings and certain group rings many results on group rings have been included some of which are published for the first time. The authors often provide a new viewpoint and novel elementary proofs in cases where results are already known The authors assume only that the reader is familiar with basic ring theoretic and group theoretic concepts They present a work which is very much self contained It is thus a valuable reference to the student as well as the research mathematician An extensive bibliography of references which are either directly relevant to the text or which offer supplementary material of interest are also included Alternative Loop Rings E.G. Goodaire, E. Jespers, C. Polcino Milies, 1996-11-07 For the past ten years alternative loop rings have intrigued mathematicians from a wide cross section of modern algebra As a consequence the theory of alternative loop rings has grown tremendously One of the main developments is the complete characterization of loops which have an alternative but not associative loop ring Furthermore there is a very close relationship between the algebraic structures of loop rings and of group rings over 2 groups Another major topic of research is the study of the unit loop of the integral loop ring Here the interaction between loop rings and group rings is of immense interest This is the first survey of the theory of alternative loop rings and related issues Due to the strong interaction between loop rings and certain group rings many results on group rings have been included some of which are published for the first time. The authors often provide a new viewpoint and novel elementary proofs in cases where results are already known The authors assume only that the reader is familiar with basic ring theoretic and group theoretic concepts They present a work which is very much self contained It is thus a valuable reference to the student as well as the research mathematician An extensive bibliography of references which are either directly relevant to the text or which offer supplementary material of interest are also included **Alternative Loop Rings** with Solvable Unit Loops Edgar G. Goodaire, Francisco César Polcino Milies, 1999 Smarandache Non-Associative Rings W. B. Vasantha Kandasamy, 2002 Generally in any human field a Smarandache Structure on a set A means a weak structure W on A such that there exists a proper subset B in A which is embedded with a stronger structure S These types of structures occur in our everyday's life that's why we study them in this book Thus as a particular case A Non associative ring is a non empty set R together with two binary operations and such that R is an additive abelian group and R is a groupoid For all a b c

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#### **Table of Contents Alternative Loop Rings**

- 1. Understanding the eBook Alternative Loop Rings
  - The Rise of Digital Reading Alternative Loop Rings
  - o Advantages of eBooks Over Traditional Books
- 2. Identifying Alternative Loop Rings
  - $\circ \ \ \textbf{Exploring Different Genres}$
  - Considering Fiction vs. Non-Fiction
  - Determining Your Reading Goals
- 3. Choosing the Right eBook Platform
  - Popular eBook Platforms
  - Features to Look for in an Alternative Loop Rings
  - User-Friendly Interface
- 4. Exploring eBook Recommendations from Alternative Loop Rings
  - Personalized Recommendations
  - Alternative Loop Rings User Reviews and Ratings

- Alternative Loop Rings and Bestseller Lists
- 5. Accessing Alternative Loop Rings Free and Paid eBooks
  - Alternative Loop Rings Public Domain eBooks
  - Alternative Loop Rings eBook Subscription Services
  - Alternative Loop Rings Budget-Friendly Options
- 6. Navigating Alternative Loop Rings eBook Formats
  - o ePub, PDF, MOBI, and More
  - Alternative Loop Rings Compatibility with Devices
  - Alternative Loop Rings Enhanced eBook Features
- 7. Enhancing Your Reading Experience
  - $\circ\,$  Adjustable Fonts and Text Sizes of Alternative Loop Rings
  - Highlighting and Note-Taking Alternative Loop Rings
  - Interactive Elements Alternative Loop Rings
- 8. Staying Engaged with Alternative Loop Rings
  - o Joining Online Reading Communities
  - Participating in Virtual Book Clubs
  - Following Authors and Publishers Alternative Loop Rings
- 9. Balancing eBooks and Physical Books Alternative Loop Rings
  - o Benefits of a Digital Library
  - Creating a Diverse Reading Collection Alternative Loop Rings
- 10. Overcoming Reading Challenges
  - Dealing with Digital Eye Strain
  - Minimizing Distractions
  - Managing Screen Time
- 11. Cultivating a Reading Routine Alternative Loop Rings
  - Setting Reading Goals Alternative Loop Rings
  - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Alternative Loop Rings
  - Fact-Checking eBook Content of Alternative Loop Rings
  - Distinguishing Credible Sources

- 13. Promoting Lifelong Learning
  - Utilizing eBooks for Skill Development
  - Exploring Educational eBooks
- 14. Embracing eBook Trends
  - Integration of Multimedia Elements
  - Interactive and Gamified eBooks

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