

Extra and Alternative Loop Rings

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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 $\sum_{i=1}^n \alpha_i x_i$ where the x_i are elements of L and the α_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 Milnes [1]. We note that L is embedded in to RL via the map $x \mapsto 1x$; we usually write the element $1x$ simply as x . In this paper we would like to focus on right alternative law $((x \cdot y)y = x(y \cdot y))$ and the left alternative law $((y \cdot y)x = y(y \cdot x))$. 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 is relevant, by the following result from [7]:

REMARK : RL is associative iff L is associative.

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 $g, h, k \in L$ do not associate, then $g \cdot kh = gh \cdot k = h \cdot gk$.

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 $gk \cdot k = gk^2$, $gh \cdot k + gk \cdot h = g \cdot hk + g \cdot kh$. Because $\text{char } R \neq 2$, $gh \cdot k$ 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 $x = \sum \alpha_i g$ and $y = \sum \beta_j g$ 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 $gh \cdot h = g \cdot hh$ 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 $(xy \cdot z)x = x(y \cdot zx)$ is clear. If x, y and z do not associative, then neither do $(xy \cdot z)x = x(y \cdot zx)$ is clear. If x, y and z do not associative, then neither do xy, z, x (again by Moufang's Theorem), so $(xy \cdot z)x = (x \cdot y)(x \cdot z)$ by Theorem 1 and, since x, y, xz do not associate, $(x \cdot y)(x \cdot z) = x(xz \cdot y)$. Repeated use of Theorem 1 gives $xz \cdot y = z \cdot xy = zy \cdot x = y \cdot zx$ and so, again $(xy \cdot z)x = x(y \cdot zx)$.

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

**W. B. Vasantha Kandasamy, Florentin
Smarandache**

Alternative Loop Rings:

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superalgebras and their representations Hopf algebras Poisson algebras Quantum Groups Group Rings and other topics

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Nonassociative Algebra and Its Applications R. Costa, 2019-05-20 A collection of lectures presented at the Fourth International Conference on Nonassociative Algebra and its Applications held in Sao Paulo Brazil Topics in algebra theory include alternative Bernstein Jordan Lie and Malcev algebras and superalgebras The volume presents applications to population genetics theory physics and more

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