

# Composition of Paraproducts

UNM - Analysis Seminar

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**Abstract.** In 2013, Pott, Reguera, Sawyer and Wick studied bounds for compositions of dyadic Haar paraproduct operators. Operators of this type are defined as

$$P_b^{(\alpha,\beta)} f := \sum_{I \in \mathcal{D}} b_I \langle f, h_I^\beta \rangle h_I^\alpha,$$

where  $\alpha, \beta \in \{0, 1\}$  and  $h_I^0$ , and  $h_I^1$  are the dyadic Haar function associated to the dyadic interval  $I \in \mathcal{D}$ , and the dyadic averaging function  $\frac{1}{|I|}$ , respectively.

The authors developed methods to study several combinations of paraproduct type operators,  $P_b^{(\alpha,\beta)}$  and  $P_d^{(\gamma,\delta)}$  giving a joint condition for their boundedness in terms of the symbols  $b$  and  $d$ . One of the cases of the compositions remained unclassified. It remained unknown what the bound of  $\Pi_b \Pi_d$ , where  $\Pi_b$ , and  $\Pi_d$  are the usual dyadic paraproduct operator. We give a bound for this operator. For the operator  $\Pi_b^* \Pi_d$ , we extend the work of Pott, Reguera, Sawyer and Wick to a weighted setting.

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