

## REMARKS ON THE METRIC INDUCED BY THE ROBIN FUNCTION

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**ABSTRACT.** Let  $D$  be a smoothly bounded pseudoconvex domain in  $\mathbb{C}^n$ ,  $n > 1$ . Using  $G(z, p)$ , the Green function for  $D$  with pole at  $p \in D$  associated with the standard sum-of-squares Laplacian, N. Levenberg and H. Yamaguchi had constructed a Kähler metric (the so-called  $A$ -metric) using the Robin function  $A(p)$  arising from  $G(z, p)$ . The purpose of this article is to study this metric by deriving its boundary asymptotics and using them to calculate the holomorphic sectional curvature along normal directions. It is also shown that the  $A$ -metric is comparable to the Kobayashi (and hence to the Bergman and Carathéodory metrics) when  $D$  is strongly pseudoconvex. The unit ball in  $\mathbb{C}^n$  is also characterized among all smoothly bounded strongly convex domains on which the  $A$ -metric has constant negative holomorphic sectional curvature. This may be regarded as a version of Lu-Qi Keng's theorem for the Bergman metric.

## 1. INTRODUCTION

Let  $D$  be a smoothly bounded domain in  $\mathbb{C}^n$ ,  $n > 1$  with smooth defining function  $\psi(z)$  so that  $D = \{\psi < 0\}$ . For  $p \in D$ , let  $G(z, p)$  be the Green function for  $D$  with pole at  $p$  associated to the standard Laplacian

$$\Delta = 4 \sum_{j=1}^n \frac{\partial^2}{\partial z_j \partial \bar{z}_j}$$

on  $\mathbb{C}^n \approx \mathbb{R}^{2n}$ . The notation for the Green function will be enhanced to  $G_D(z, p)$  if the need to emphasize its dependence on  $D$  arises. Then  $G(z, p)$  is the unique function satisfying  $\Delta G(z, p) = 0$  on  $D \setminus \{p\}$ ,  $G(z, p) \rightarrow 0$  as  $z \rightarrow \partial D$  and  $G(z, p) - |z - p|^{-2n+2}$  is harmonic near  $p$ . Let  $H_p(z)$  be harmonic on  $D$ , continuous on  $\bar{D}$  and such that  $H_p(z) = -|z - p|^{-2n+2}$  for  $z \in \partial D$ . The existence of such a function is guaranteed by the solution to the Dirichlet problem and

$$G(z, p) = |z - p|^{-2n+2} + H_p(z)$$

is then the Green function for  $D$  with pole at  $p$ . Therefore

$$A(p) := \lim_{z \rightarrow p} \left( G(z, p) - |z - p|^{-2n+2} \right)$$

exists for each  $p \in D$  and is called the Robin constant at  $p$  and the map  $p \mapsto A(p)$  is the Robin function for  $D$ . Said differently  $A(p) = H_p(0)$ . Hence it is possible to rewrite the expression for  $G(z, p)$  as

$$(1.1) \quad G(z, p) = |z - p|^{-2n+2} + A(p) + h_p(z)$$

where  $h_p(z) = H_p(z) - H_p(0)$  is harmonic on  $D$  and satisfies  $h_p(p) = 0$  for all  $p \in D$ . The maximum principle implies that  $A(p) < 0$  for all  $p \in D$  and it was shown by Yamaguchi in [13] that  $p \mapsto -A(p)$  is a real analytic exhaustion function for  $D$ . The assertion that  $A(p)$  is real analytic is entirely local and as such does not require any smoothness hypothesis on  $\partial D$  while the latter statement that  $-A(p)$  is an exhaustion only needs the domain to be one where the Dirichlet problem can be solved. These claims are therefore valid on a much larger class of bounded domains than the smoothly bounded ones, the point here of course being that the smoothness assumption on  $\partial D$  does not play any vital role so far. Further understanding of the Robin function came through the work of Levenberg-Yamaguchi ([10]) where they derived explicit expressions for the complex Hessians of  $-A$  and  $\log(-A)$  on smoothly bounded domains using the technique of variation of domains. To describe this briefly, fix  $p_0 \in D$  and  $a \in \mathbb{C}^n$  a non-zero

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