TAUBERIAN THEOREMS WITH REMAINDER

E. OMEY

ABSTRACT

Suppose that $f, g: \mathbb{R}_+ \to \mathbb{R}_+$ are non decreasing functions of x with finite Laplace transforms $\bar{f}(x)$ and $\bar{g}(x)$, respectively.

In this paper we discuss conditions under which, as $x \to \infty$, $\bar{f}(1/x) - \bar{g}(1/x) = O(n(x))$ implies that $f(x) - g(x) = O(h(x))$ for certain classes of functions $g(x)$, $n(x)$ and $h(x)$, thereby extending a result of Ingham.

As a corollary we also obtain an Abel–Tauber theorem for regularly varying functions with remainder, that is, under certain conditions on $f(x)$ and $u(x)$ we prove, as $x \to \infty$, that $f(x)/f(t) = x^{\beta} + O(n(x))$ if and only if $\bar{f}(1/xx)/\bar{f}(1/x) = x^{\beta} + O(n(x))$.

1. Introduction

Tauberian theorems, connecting the limiting behaviour of a non-decreasing function f and its Laplace transform $\bar{f}(x) = x \int_0^\infty e^{-xt} f(x)\, dx$, $x > 0$, were proved, among others, by Karamata [23] and Hardy and Littlewood [19, Theorem 108] in case of regularly varying functions, that is, measurable functions $f: \mathbb{R}_+ \to \mathbb{R}_+$ for which

$$\lim_{t \to \infty} \frac{f(tx)}{f(t)} = x^{\beta}$$

for all $x > 0$ and some $\beta \in \mathbb{R}$. In this case the relation

$$\bar{f}(1/x) = \alpha f(x) + \varepsilon(x) f(x) \qquad (1.1)$$

is valid, where α is a constant and $\varepsilon(x) \to 0$ as $x \to \infty$.

Several papers (for example [7, 8, 13, 21, 22]) consider the hypothesis (1.1) where $\alpha \neq 0$ and

$$\varepsilon(x) \to 0 \qquad \text{as } x \to \infty \qquad (1.2)$$

or

$$\varepsilon(x) \to 0 \qquad \text{at a known rate as } x \to \infty \qquad (1.3)$$

and establish that f has some type of regular asymptotic behaviour as $x \to \infty$. The best known result concerning (1.1) and (1.2) is contained as a special case in [21, Theorem 1] or [7, 8, Theorem 6.2] where it is shown that (1.2) with $\alpha > 0$ and (1.2) imply regular variation of f and $\bar{f}$. In case (1.1) and (1.3) hold Jordan [22] obtains some precise asymptotic estimates for f, assuming that $\varepsilon(x) = x^{-\delta}$ for some $\delta > 0$. For other results of this type we refer to [2, 3, 11, 13, 27, 28]. If one considers Tauberian theorems connecting

$$f(xt) = g(x) + \varepsilon_1(x) g(x) \qquad (1.4)$$

and

$$\bar{f}(1/x) = \bar{g}(1/x) + \varepsilon_2(x) \bar{g}(1/x), \qquad (1.5)$$

where $\varepsilon_i(x) \to 0$ as $x \to \infty$ ($i = 1, 2$), Stadtmüller and Trautner [31] have shown that

Tauberian Remainder Theorems

Daniel F McAuley

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