

# ON THE BOHR TRANSFORM OF ALMOST-PERIODIC SOLUTIONS FOR SOME DIFFERENTIAL EQUATIONS IN ABSTRACT SPACES

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**ABSTRACT.** We consider abstract differential equations of the form  $u'(t) = Au(t) + f(t)$  or  $u''(t) = Au(t) + f(t)$  in Banach spaces  $X$ , where  $f(\cdot), \mathbb{R} \rightarrow X$  is almost-periodic, while  $A$  is a linear operator,  $\mathfrak{D}(A) \subset X \rightarrow X$ . If the solution  $u(\cdot)$  is likewise almost-periodic,  $\mathbb{R} \rightarrow X$ , we establish connections between their Bohr-transforms,  $\hat{u}(\lambda)$  and  $\hat{f}(\lambda)$ .

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**1. Introduction.** If  $u(\cdot), \mathbb{R} \rightarrow X$  (a Banach space) is an ultraweak almost-periodic solution of the differential equation

$$u'(t) = Au(t) + f(t), \quad t \in \mathbb{R} \text{ (first order)} \quad (1.1)$$

or

$$u''(t) = Au(t) + f(t), \quad t \in \mathbb{R} \text{ (second order)} \quad (1.2)$$

with linear—not necessarily continuous—operator  $A, \mathfrak{D}(A) \subset X \rightarrow X$ , and with almost-periodic “forcing” term  $f(\cdot), \mathbb{R} \rightarrow X$ , then the Bohr transforms

$$\hat{f}(\lambda) = \lim_{T \rightarrow \infty} \frac{1}{T} \int_0^T e^{-i\lambda t} f(t) dt, \quad \hat{u}(\lambda) = \lim_{T \rightarrow \infty} \frac{1}{T} \int_0^T e^{-i\lambda t} u(t) dt, \quad (1.3)$$

will both exist, for all reals  $\lambda$ .

It appears that it is possible to establish a typical relationship between  $\hat{u}(\lambda)$  and  $\hat{f}(\lambda)$  which implies also connections between the (countable) sets

$$\Lambda_u = \{\lambda \in \mathbb{R}, \hat{u}(\lambda) \neq \emptyset\}, \quad \Lambda_f = \{\lambda \in \mathbb{R}, \hat{f}(\lambda) \neq \emptyset\}, \quad (1.4)$$

(the elements of  $\Lambda_u, \Lambda_f$  are the Fourier “exponents” of  $u(\cdot), f(\cdot)$ , resp.).

Some “historical” notes:

(i) In [7] we have (1.2) in a Hilbert space, with  $A \geq \Theta$ , and the solution is in the usual sense. One obtains the equality

$$(\lambda^2 + \tilde{A}) \hat{u}(\lambda) = -\hat{f}(\lambda), \quad \forall \lambda \in \mathbb{R}, \quad (1.5)$$

where  $\tilde{A}$  is a selfadjoint extension of  $A$ .

(ii) In [6] the equation is (1.1) and  $f$  is continuous almost-periodic in Stepanoff  $S^p$ -sense; the operator  $A$  is closed in  $X$ . One gets the equality

$$(i\lambda - A) \hat{u}(\lambda) = \hat{f}(\lambda). \quad (1.6)$$

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**Daniel F McAuley**



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