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ON WEAKLY B-IRRESOLUTE FUNCTIONS

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Abstract. The concept of b-open sets was introduced by Andrijevic. The aim of this paper is to introduce and characterize weakly b-irresolute functions by using b-open sets.

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1. Introduction

As generalization of open sets, b-open sets were introduced and studied by Andrijevic. This notions was further studied by Ekici [3, 4, 5], Park [7] and Caldas et al [2]. In this paper, we will continue the study of related functions with b-open [1] sets. We introduce and characterize the concepts of weakly b-irresolute functions and relationships between strongly b-irresolute functions and graphs are investigated. Throughout this paper, X and Y refer always topological spaces on which no separation axioms are assumed unless otherwise mentioned. For a subset A of X, $\mathrm{Cl}(A)$ and $\mathrm{Int}(A)$ denote the closure of A and interior of A in X, respectively. A subset A of X is said to be b-open [1] if $A \subset \mathrm{Cl}(\mathrm{Int}(A)) \cup \mathrm{Int}(\mathrm{Cl}(A))$. The complement of b-open set is called b-closed. The intersection of all b-closed sets of X containing A is called the b-closure [1] of A and is denoted by $b\,\mathrm{Cl}(A)$. A set A is b-closed if and only if $b\,\mathrm{Cl}(A) = A$. The union of all b-open sets of X contained in A is called the b-interior of A and is denoted by $b\,\mathrm{Int}(A)$. A set A is said to be b-regular [7] if it is b-open and b-closed. The family of all b-open (resp. b-closed, b-regular) sets of X is denoted by $BO(X)$ (resp. $BC(X)$, $BR(X)$). We have set $BO(X, x) = \{V \in BO(X) | x \in V\}$ for $x \in X$.

2. Preliminaries

A point x of X is called a b-θ-cluster [7] points of $S \subset X$ if $b\,\mathrm{Cl}(U) \cap S \neq \emptyset$ for every $U \in BO(X, x)$. The set of all b-θ-cluster points of S is called the b-θ-closure of S and is denoted by $b\,\mathrm{Cl}_\theta(S)$. A subset S is said to be b-θ-closed if and only if $S = b\,\mathrm{Cl}_\theta(S)$. The complement of a b-θ-closed set is said to be b-θ-open.

Theorem 1 *[7] Let A be a subset of a topological space X. Then,*

(i) $A \in BO(X)$ if and only if $b\,\mathrm{Cl}(A) \in BR(X)$.

(ii) $A \in BO(X)$ if and only if $b\,\mathrm{Int}(A) \in BR(X)$.

Theorem 2 *[7] For a subset A of a topological space X, the following properties hold:*

(i) If $A \in BO(X)$, then $b\,\mathrm{Cl}(A) = b\,\mathrm{Cl}_\theta(A)$,

(ii) $A \in BR(X)$ if and only if A is b-θ-open and b-θ-closed.

Definition 1 *[7] A topological space X is said to be b-regular if for each $F \in BC(X)$ and each $x \notin F$, there exist disjoint b-open sets U and V such that $x \in U$ and $F \subset V$.*

Theorem 3 *[7] For a topological space X, the following properties are equivalent:*

(i) X is b-regular;

(ii) For each $U \in BO(X)$ and each $x \in U$, there exists $V \in BO(X)$ such that $x \in V \subset b\,\mathrm{Cl}(V) \subset U$;

(iii) For each $U \in BO(X)$ and each $x \in U$, there exists $V \in BR(X)$ such that $x \in V \subset U$.

Definition 2 *A function $f : X \to Y$ is said to be b-irresolute [6] if $f^{-1}(V) \in BO(X)$ for every $V \in BO(Y)$.*

3.Weakly b-irresolute functions

We have introduce the following definition

Definition 3 *A function $f : X \to Y$ is said to be weakly b-irresolute if for each $x \in X$ and each $V \in BO(Y, f(x))$, there exists $U \in BO(X, x)$ such that $f(U) \subset b\,\mathrm{Cl}(V)$.*

Clearly, every b-irresolute function is weakly b-irresolute but the converse is not true, in general, as shown by the following example.

Example 1 *Let* $X = \{a, b, c\} = Y$, $\tau = \{\emptyset, \{a\}, X\}$ *and* $\sigma = \{\emptyset, \{b\}, Y\}$. *Define a function* $f : X \to Y$ *such that* $f(a) = a$, $f(b) = c$ *and* $f(c) = b$. *Then, clearly* f *is weakly b-irresolute but not b-irresolute.*

Theorem 4 *For a function* $f : X \to Y$, *the following properties are equivalent:*

(i) f *is weakly b-irresolute;*

(ii) $f^{-1}(V) \subset b\,\mathrm{Int}(f^{-1}(b\,\mathrm{Cl}(V)))$ *for every* $V \in BO(Y)$*;*

(iii) $b\,\mathrm{Cl}(f^{-1}(V)) \subset f^{-1}(b\,\mathrm{Cl}(V))$ *for every* $V \in BO(Y)$.

Proof. **(i)⇒(ii):** Suppose that $V \in BO(Y)$ and let $x \in f^{-1}(V)$. By (i), $f(U) \subset b\,\mathrm{Cl}(V)$ for some $U \in BO(X, x)$. Therefore, we have $U \subset f^{-1}(b\,\mathrm{Cl}(V))$ and $x \in U \subset b\,\mathrm{Int}(f^{-1}(b\,\mathrm{Cl}(V)))$. This shows that $f^{-}(V) \subset b\,\mathrm{Int}(f^{-1}(b\,\mathrm{Cl}(V)))$.
(ii)⇒(iii): Suppose that $V \in BO(Y)$ and $x \notin f^{-1}(b\,\mathrm{Cl}(V))$. Then $f(x) \notin b\,\mathrm{Cl}(V)$. There exists $F \in BO(Y, f(x))$ such that $F \cap V = \emptyset$. Since $V \in BO(Y)$, we have $b\,\mathrm{Cl}(F) \cap V = \emptyset$ and hence $b\,\mathrm{Int}(f^{-1}(b\,\mathrm{Cl}(F))) \cap f^{-1}(V) = \emptyset$. By (ii), we have $x \in f^{-1}(F) \subset b\,\mathrm{Int}(f^{-1}(b\,\mathrm{Cl}(F))) \in BO(X)$. Therefore, we obtain $x \notin b\,\mathrm{Cl}(f^{-1}(V)) \subset f^{-1}(b\,\mathrm{Cl}(V))$.
(iii)⇒(i): Let $x \in X$ and $V \in BO(Y, f(x))$. By Theorem 1, $b\,\mathrm{Cl}(V) \in BR(Y)$ and $x \notin f^{-1}(b\,\mathrm{Cl}(Y - b\,\mathrm{Cl}(V)))$. Since $Y - b\,\mathrm{Cl}(V) \in BO(Y)$, by (iii), we have $x \notin b\,\mathrm{Cl}(f^{-1}(Y - b\,\mathrm{Cl}(V)))$. Hence there exists $F \in BO(X, x)$ such that $F \cap f^{-1}(Y - b\,\mathrm{Cl}(V)) = \emptyset$. Therefore, we obtain $f(F) \cap (Y - b\,\mathrm{Cl}(V)) = \emptyset$ and hence $f(F) \subset b\,\mathrm{Cl}(V)$. This shows that f is weakly b-irresolute.

Theorem 5 *For a function* $f : X \to Y$, *the following properties are equivalent:*

(i) f *is weakly b-irresolute;*

(ii) $b\,\mathrm{Cl}(f^{-1}(B)) \subset f^{-1}(bcl_\theta(B))$ *for every subset* B *of* Y*;*

(iii) $f(b\,\mathrm{Cl}(A)) \subset b\,\mathrm{Cl}_\theta(f(A))$ *for every subset* A *of* X*;*

(iv) $f^{-1}(F) \in BC(X)$ *for every b-θ-closed set* F *of* Y*;*

(v) $f^{-1}(V) \in BO(X)$ *for every b-θ-open set* V *of* Y.

Proof. **(i)⇒(ii):** Let B be any subset of Y and $x \notin f^{-1}(b\,\mathrm{Cl}_\theta(B))$. Then $f(x) \notin b\,\mathrm{Cl}_\theta(B)$ and there exists $V \in BO(Y, f(x))$ such that $b\,\mathrm{Cl}(V) \cap B = \emptyset$. By (i), there exists $U \in BO(X, x)$ such that $f(U) \subset b\,\mathrm{Cl}(V)$. Hence $f(U) \cap B = \emptyset$ and $U \cap f^{-1}(B) = \emptyset$. Consequently, we obtain $x \notin b\,\mathrm{Cl}(f^{-1}(B))$.
(ii)⇒(iii): Let A be any subset of X. By (ii), we have $b\,\mathrm{Cl}(A) \subset b\,\mathrm{Cl}(f^{-1}(f(A)))$

$\subset f^{-1}(b\,\mathrm{Cl}_\theta(f(A)))$ and hence $f(b\,\mathrm{Cl}(A)) \subset b\,\mathrm{Cl}_\theta(f(A))$.
(iii)⇒(iv): Let F be any b-θ-closed set of Y. Then, by (iii), we have $f(b\,\mathrm{Cl}(f^{-1}(F))) \subset b\,\mathrm{Cl}_\theta(f(f^{-1}(F))) \subset b\,\mathrm{Cl}_\theta(F) = F$. Therefore, we have $b\,\mathrm{Cl}(f^{-1}(F)) \subset f^{-1}(F)$ and hence $b\,\mathrm{Cl}(f^{-1}(F)) = f^{-1}(F)$. This shows that $f^{-1}(F) \in BC(X)$.
(iv)⇒(v): This is obvious.
(v)⇒(i): Let $x \in X$ and $V \in BO(Y, f(x))$. By Theorems 1 and 2, $b\,\mathrm{Cl}(V)$ is b-θ-open in Y. Put $U = f^{-1}(b\,\mathrm{Cl}(V))$. Then by (v), $U \in BO(X, x)$ and $f(U) \subset b\,\mathrm{Cl}(V)$. Thus, f is weakly b-irresolute.

Theorem 6 *For a function $f : X \to Y$, the following properties are equivalent:*

(i) f is weakly b-irresolute;

(ii) for each $x \in X$ and each $V \in BO(Y, f(x))$ there exists $U \in BO(X, x)$ such that $f(b\,\mathrm{Cl}(U)) \subset b\,\mathrm{Cl}(V)$;

(iii) $f^{-1}(F) \in BR(X)$ for every $F \in BR(Y)$.

Proof. **(i)⇒(ii):** Let $x \in X$ and $V \in BO(Y, f(x))$. Then $b\,\mathrm{Cl}(V)$ is b-θ-open and b-θ-closed in Y, by Theorems 1 and 2. Now, put $U = f^{-1}(b\,\mathrm{Cl}(V))$. Then by Theorem 5, $U \in BR(X)$ and hence $U \in BO(X, x)$. Therefore, $U = b\,\mathrm{Cl}(U)$ and $f(b\,\mathrm{Cl}(U)) \subset b\,\mathrm{Cl}(V)$.
(ii)⇒(iii): Let $F \in BR(Y)$ and $x \in f^{-1}(F)$. Then $f(x) \in F$. By (ii), there exists $V \in BO(X, x)$ such that $f(b\,\mathrm{Cl}(U)) \subset F$. Therefore, we have $x \in U \subset b\,\mathrm{Cl}(U) \subset f^{-1}(F)$ and hence $f^{-1}(F) \in BO(X)$. Since $Y - F \in BR(Y)$, $f^{-1}(Y - F) = X - f^{-1}(F) \in BO(X)$. Therefore, we obtain $f^{-1}(F) \in BC(X)$ and hence $f^{-1}(F) \in BR(X)$.
(iii)⇒(i): Let $x \in X$ and $V \in BO(Y, f(x))$. By Theorem 1, $b\,\mathrm{Cl}(V) \in BR(Y, f(x))$ and $f^{-1}(b\,\mathrm{Cl}(V)) \in BR(X, x)$. Set $U = f^{-1}(b\,\mathrm{Cl}(V))$. Then $U \in BO(X, x)$ and $f(U) \subset b\,\mathrm{Cl}(V)$. This shows that f is weakly b-irresolute.

The proof of the following two theorems are similar to Theorem 5 and 6.

Theorem 7 *For a function $f : X \to Y$, the following properties are equivalent:*

(i) f is weakly b-irreslute;

(ii) $f^{-1}(V) \subset b\,\mathrm{Int}_\theta(f^{-1}(b\,\mathrm{Cl}_\theta(V)))$ for every $V \in BO(Y)$;

(iii) $b\,\mathrm{Cl}_\theta(f^{-1}(V)) \subset f^{-1}(b\,\mathrm{Cl}_\theta(V))$ for every $V \in BO(Y)$.

Theorem 8 *For a function $f : X \to Y$, the following properties are equivalent:*

(i) f *is weakly* b*-irreslute;*

(ii) $b\,\mathrm{Cl}_\theta(f^{-1}(B)) \subset f^{-1}(b\,\mathrm{Cl}_\theta(B))$ *for every subset* B *of* Y*;*

(iii) $f(b\,\mathrm{Cl}_\theta(A)) \subset b\,\mathrm{Cl}_\theta(f(A))$ *for every subset* A *of* X*;*

(iv) $f^{-1}(F)$ *is* b*-*θ*-closed in* X *for every* b*-*θ*-closed set* F *of* Y*.*

(v) $f^{-1}(V)$ *is* b*-*θ*-open in* X *for every* b*-*θ*-closed set* V *of* Y*.*

Theorem 9 *Let* Y *be* b*-regular space. Then a function* $f : X \to Y$ *is weakly* b*-irresolute if and only if it is* b*-irresolute.*

Proof. Suppose that $f : X \to Y$ is weakly b-irresolute. Let V be any b-open set of Y and $x \in f^{-1}(V)$. Then $f(x) \in V$. Since Y is b-regular, by Theorem 3 there exists $F \in BO(Y)$ such that $f(x) \in F \subset b\,\mathrm{Cl}(W) \subset V$. Since f is weakly b-irresolute, there exists $U \in BO(X, x)$ such that $f(U) \subset b\,\mathrm{Cl}(F)$. Therefore, we have $x \in U \subset f^{-1}(V)$ and $f^{-1}(V) \in BO(X)$. This shows that f is b-irresolute.

Theorem 10 *A function* $f : X \to Y$ *is weakly* b*-irresolute if the graph function, defined by* $g(x) = (x, f(x))$ *for each* $x \in X$*, is weakly* b*-irresolute.*

Proof. Let $x \in X$ and $V \in BO(Y, f(x))$. Then $X \times V$ is a b-open subset of $X \times Y$ containing $g(x)$. Since g is weakly b-irresolute, there exists $U \in BO(X, x)$ such that $g(U) \subset b\,\mathrm{Cl}(X \times V) \subset X \times b\,\mathrm{Cl}(V)$. Therefore, we obtain $f(U) \subset b\,\mathrm{Cl}(V)$.

Recall that a topological space X is said to be b-T_2 [7] if for each pair of distinct points $x, y \in X$, there exists $U \in BO(X, x)$ and $V \in BO(X, y)$ such that $U \cap V = \emptyset$.

Lemma 11 *[7] A topological space* X *is* b*-*T_2 *if and only if for each pair of distinct points* $x, y \in X$*, there exists* $U \in BO(X, x)$ *and* $V \in BO(X, y)$ *such that* $b\,\mathrm{Cl}(U) \cap b\,\mathrm{Cl}(V) = \emptyset$*.*

Theorem 12 *If* Y *is* b*-*T_2 *space and* $f : X \to Y$ *is a weakly* b*-irresolute injection, then* X *is* b*-*T_2*.*

Proof. Let x, y be any distinct points of X. Since f is injective, we have $f(x) \neq f(y)$. Since Y is b-T_2, by Lemma 11 there exists $V \in BO(Y, f(x))$ and $W \in BO(Y, f(y))$ such that $b\,\mathrm{Cl}(V) \cap b\,\mathrm{Cl}(W) = \emptyset$. Since f is weakly b-irresolute, there exists $G \in BO(X, x)$ and $H \in BO(X, y)$ such that $f(G) \subset b\,\mathrm{Cl}(V)$ and $f(H) \subset b\,\mathrm{Cl}(W)$. Therefore, we obtain $G \cap H = \emptyset$ and hence X is b-T_2.

Definition 4 *A function $f : X \to Y$ is said to have a strongly b-closed graph if for each $(x, y) \in (X \times Y) - G(f)$, there exists $U \in BO(X, x)$ and $V \in BO(Y, y)$ such that $(b\,\mathrm{Cl}(U) \times b\,\mathrm{Cl}(V)) \cap G(f) = \emptyset$.*

Theorem 13 *If Y is a b-T_2 space and $f : X \to Y$ is weakly b-irresolute, then $G(f)$ is strongly b-closed.*

Proof. Let $(x, y) \in (X \times Y) - G(f)$. Then $y \neq f(x)$ and by Lemma 11, there exist $V \in BO(Y, f(x))$ and $W \in BO(Y, y)$ such that $b\,\mathrm{Cl}(V) \cap b\,\mathrm{Cl}(W) = \emptyset$. Since f is weakly b-irresolute, by Theorem 6 there exists $U \in BO(X, x)$ such that $f(b\,\mathrm{Cl}(U)) \subset b\,\mathrm{Cl}(V)$. Therefore, we obtain $f(b\,\mathrm{Cl}(U)) \cap b\,\mathrm{Cl}(W) = \emptyset$ and hence $(b\,\mathrm{Cl}(U) \times b\,\mathrm{Cl}(W)) \cap G(f) = \emptyset$. This shows that $G(f)$ is strongly b-closed in $X \times Y$.

Theorem 14 *If a function $f : X \to Y$ is weakly b-irresolute, injective and $G(f)$ is strongly b-closed, then X is b-T_2.*

Proof. Let x, y be a pair of distinct points of X. Since f is injective, $f(x) \neq f(y)$ and $(x, f(y)) \notin G(f)$. Since $G(f)$ is strongly b-closed, there exist $U \in BO(X, x)$ and $V \in BO(Y, f(y))$ such that $f(b\,\mathrm{Cl}(U)) \cap b\,\mathrm{Cl}(V) = \emptyset$. Since f is weakly b-irresolute, there exists $H \in BO(X, y)$ such that $f(H) \subset b\,\mathrm{Cl}(V)$. Therefore, we obtain $f(b\,\mathrm{Cl}(G)) \cap f(H) = \emptyset$ and hence $G \cap H = \emptyset$. This shows that X is b-T_2.

Recall that a topological space X is said to be b-connected [7] if it cannot be written as the union of two non-empty disjoint b-open sets.

Theorem 15 *If a function $f : X \to Y$ is a weakly b-irresolute surjection and X is b-connected, then Y is b-connected.*

Proof. Suppose that Y is not b-connected. Then there exists nonempty b-open sets U and V of Y such that $U \cup V = Y$ and $U \cap V = \emptyset$. Then we have $U, V \in BR(Y)$. By Theorem 6, $f^{-1}(U)$, $f^{-1}(V) \in BR(X)$ since f is weakly b-irresolute. Moreover, we have $f^{-1}(U) \cup f^{-1}(V) = X$, $f^{-1}(U) \cap f^{-1}(V) = \emptyset$, and $f^{-1}(U)$ and $f^{-1}(V)$ are non-empty. Therefore, X is not b-connected.

The following example shows that the image of a b-connected set under a weakly b-irresolute function is not necessarily b-connected.

Example 2 *Let $X = \{a, b, c\}$, τ be the indiscrete topology and $\sigma = \{\emptyset, \{c\}, \{a, c\}, \{b, c\}, X\}$. The function $f : (X, \tau) \to (Y, \sigma)$ defined by $f(a) = a$ and $f(b) = f(c) = b$ is weakly b-irresolute. Moreover, X is b-connected but $f(X)$ is not b-connected.*

Definition 5 *A function $f : X \to Y$ is said to be almost b-irresolute if for each point $x \in X$ and each b-open set containing $f(x)$, $b\,\mathrm{Cl}(f^{-1}(V)) \in BO(X, x)$.*

An almost b-irresolute function need not be weakly b-irresolute, as show by the following example.

Example 3 *Let $X = \{a, b, c\}$ and $\tau = \{\emptyset, \{a\}, \{a, b\}, \{a, c\}, X\}$. Then the function $f : X \to Y$ defined by $f(a) = f(c) = b$ and $f(b) = c$ is weakly b-irresolute but not b-irresolute.*

Theorem 16 *If $f : X \to Y$ is almost b-irresolute adn $b\,\mathrm{Cl}(f^{-1}(V)) \subset f^{-1}(b\,\mathrm{Cl}(V))$ for each $V \in BO(Y)$, then f is weakly b-irresolute.*

Proof. For any point $x \in X$ and $V \in BO(X, f(x))$, we have $b\,\mathrm{Cl}(f^{-1}(V)) \subset f^{-1}(b\,\mathrm{Cl}(V))$ by hypothesis. Since f is almost b-irresolute, there exists $U \in BO(X, x)$ such that $x \in U \subset b\,\mathrm{Cl}(f^{-1}(V)) \subset f^{-1}(b\,\mathrm{Cl}(V))$. Thus, $f(U) \subset b\,\mathrm{Cl}(V)$. The converse to Theorem 16 does not hold, in general, as shown by the following example.

Example 4 *Let $X = \{a, b, c\} = Y$, $\tau = \{\emptyset, \{a\}, X\}$ and $\sigma = \{\emptyset, \{b\}, Y\}$. Define a function $f : X \to Y$ such that $f(a) = a$, $f(b) = c$ and $f(c) = b$. Then, clearly f is weakly b-irresolute but not b-irresolute.*

Theorem 17 *An almost b-irresolute function $f : X \to Y$ is weakly b-irresolute if and only if $b\,\mathrm{Cl}(f^{-1}(V)) \subset f^{-1}(b\,\mathrm{Cl}(V))$.*

Proof. The proof follows from Theorems 4 and 16.

Definition 6 *Let A be a subset of a space X. The weakly b-irresolute function from X onto a subspace A of X is called a weakly b-irresolute retraction if the restriction $f_{|A}$ is the identity function on A. We call such an A a weakly b-irresolute retract of X.*

Lemma 18 *[1] If A is b-open and U is open in a space X, then $A \cap U$ is b-open in X.*

Theorem 19 *Let A be a subset of a space X and $f : X \to A$ be a weakly b-irresolute retraction of X onto A. If X is T_2, then A is b-closed in X.*

Proof. Suppose A is not b-closed. Then there exists a b-limit point x of A in X such that $x \in b\,\mathrm{Cl}(A)$ but $x \notin A$. Since f is weakly b-irresolute retraction, $f(x) \neq x$. Since X is T_2, there exist disjoint open sets, say, U and V containing x and $f(x)$, respectevely. Thus, $U \cap \mathrm{Cl}(V) = \emptyset$. Also, $V \cap A$ is open in A; hence $V \cap A \in BO(A, f(x))$. Let $W \in BO(X, x)$. Then $U \cap W \in BO(X, x)$, by Lemma 18, and hence $(U \cap W) \cap A \neq \emptyset$ because $x \in bd(A)$. Therefore, there exists a point $y \in (U \cap W \cap A)$. Since $y \in A$, $f(y) = y \in U$ and hence $f(y) \notin \mathrm{Cl}(V)$. This shows that $f(W) \subset \mathrm{Cl}(V)$. Now, $\mathrm{Cl}(V \cap A) = \mathrm{Cl}(V \cap A) \cap A \subset \mathrm{Cl}(V)$. Therefore, $f(W)$ is not a subset of $\mathrm{Cl}(V \cap A)$, which implied that $f(W)$ is not a subset of $b\,\mathrm{Cl}(V \cap A)$. This contradicts the hypothesis that f is weakly b-irresolute. Thus, A is b-closed in X. In Theorem 19, X is necessary T_2, as shown by the following example.

Example 5 *Let $X = \{a, b, c\} = Y$, $\tau = \{\emptyset, \{a\}, X\}$ and $\sigma = \{\emptyset, \{b\}, Y\}$. Define a function $f : X \to Y$ such that $f(a) = a$, $f(b) = c$ and $f(c) = b$. Then, clearly f is weakly b-irresolute but not b-irresolute.*

References

[1] D. Andrijevic, *On b-open sets*, Math. Vesnik, 48(1996), 59–64.

[2] M. Caldas, S. Jafari and T. Noiri, *On $\wedge_b$-sets and the associated topology $\tau^{\wedge_b}$*, Acta. Math. Hungar., 110(4), (2006), 337-345.

[3] E. Ekici, *On γ-US-spaces*, Indian J. Math., 47, 2-3(2005), 131-138.

[4] E. Ekici, *On R-spaces* , Int. J. Pure. Appl. Math., 25(2)(2005), 163–172.

[5] E. Ekici and M. Caldas, *Slightly γ-continuous functions*, Bol. Soc. Paran. Mat. (3s) V.22, 2 (2004), 63-74.

[6] A. A. El-Abik, *A study of some types of mappings on topological spaces* , Master's Thesis, Faculty of Science, Tanta University, Tanta, Egypt (1997).

[7] J. H. Park, *Strongly θ-b-continuous functions*, Acta Math. Hungar., 110(4)2006, 347-359.

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