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27th October 2021

Jointly Organized by

Department of Biological Science, Physical Science and Computational Science

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ABOUT THE INSTITUTION

A nations's growth is in proportion to education and intelligence spread among the masses. Having this idealistic vision, two great philanthropists late. S.P. Nallamuthu Gounder and Late. Arutchelver Padmabhushan Dr.N.Mahalingam formed an organization called Pollachi Kalvi Kazhagam, which started NGM College in 1957, to impart holistic education with an objective to cater to the higher educational needs of those who wish to aspire for excellence in knowledge and values. The College has achieved greater academic distinctions with the introduction of autonomous system from the academic year 1987-88. The college has been Re-Accredited by NAAC and it is ISO 9001 : 2015 Certified Institution. The total student strength is around 6000. Having celebrated its Diamond Jubilee in 2017, the college has blossomed into a premier Post-Graduate and Research Institution, offering 26 UG, 12 PG, 13 M.Phil and 10 Ph.D Programmes, apart from Diploma and Certificate Courses. The college has been ranked within Top 100 (72nd Rank) in India by NIRF 2021.

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The International conference on “Emerging Trends in Science and Technology (ETIST-2021)” is being jointly organized by Departments of Biological Science, Physical Science and Computational Science - Nallamuthu Gounder Mahalingam College, Pollachi along with ISTE, CSI, IETE, IEE & RIYASA LABS on 27th OCT 2021. The Conference will provide common platform for faculties, research scholars, industrialists to exchange and discus the innovative ideas and will promote to work in interdisciplinary mode.

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ON AMPLY SOFT TOPOLOGICAL SPACES

A. Revathy[1], **S. Krishnaprakash**[2] **V. Inthumathi**[3]

Abstract - In this paper we study the properties of amply soft neighbourhood, amply soft open sets, amply soft closed sets, amply soft interior and amply soft closure. Also we define the notion of amply soft exterior, amply soft boundary and investigate their properties.

Keywords *soft sets, amply soft sets, amply soft topology*
2010 Subject classification:*54A05, 54A10, 54B05*

1 Introduction

In 1999 Molodtsov [7] initiated the theory of soft sets as a new mathematical tool to deal with uncertainties while modeling problems in engineering physics, computer science, economics, social sciences and medical sciences. In particular, to keep some classical set-theoretic laws true for soft sets, Ali et al[1] defined some restricted operations on soft sets such as the restricted intersection, the restricted union, and the restricted difference and improved the notion of complement of a soft set. Later other authors like Maji et al. [5,6]have further studied the theory of soft sets and used this theory to solve some decision making problems. In 2011, Shabir and Naz [10] initiated the concept of soft topological spaces using soft sets that are defined over an initial universe set with a fixed set of parameters. After the inception of soft topology, many authors have investigated soft topological concepts analogously with their counterparts on classical topology. The different types of belong and non-belong relations on soft setting leads to introduce several types of soft axioms in terms of ordinary points and soft points. Cagman et al. [2] defined a soft topology in that they use different parameter sets in their soft sets that are finite because of the definition of soft operations. Orhan Gocur(8) introduced a new topology called Amply soft topology by which he has proved that it is not necessary for the topologies of each dimension have to be same of any space. Amply soft sets use any kind of universal parameter set or initial universe (such as finite or infinite, countable or uncountable).

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2 Preliminaries

Definition 2.1. *[8] Let $P(X)$ denote the power set of X. If $F : E \to P(X)$ is a mapping given by*

$$F(e) = \begin{cases} F(e), \forall e \in A; \\ \emptyset, \forall e \in E - A \end{cases}$$

then F with A is called as an amply soft set over X and it is denoted by $F * A$.

Definition 2.2. *[8] Let $F * A$ and $G * B$ be two amply soft sets sets over X.*

1. *$F * A$ is a subset of $G * B$, denoted by $F * A \mathrel{\tilde{\subseteq}} G * B$, if $F(e) \mathrel{\tilde{\subseteq}} G(e)$, for all $e \in A$.*
2. *$F * A$ is a superset of $G * B$, denoted by $F * A \mathrel{\tilde{\supseteq}} G * B$, if $F(e) \mathrel{\tilde{\supseteq}} G(e)$, for all $e \in B$.*

Definition 2.3. *[8] Let $F * A$ and $G * B$ be two amply soft sets over X. If $F * A$ is a subset of $G * B$ and $G * B$ is a subset of $F * A$, then $F * A$ and $G * B$ are said to be an equal and denoted by $F * A \mathrel{\tilde{=}} G * B$.*

Definition 2.4. *[8] An amply soft $F * A$ over X is said to be an*

1. *empty amply soft set denoted by $\tilde{\emptyset}$ if $F(e) = \emptyset$ for all $e \in E$.*
2. *absolute amply soft set denoted by $\tilde{X}$ if for all $e \in E$, $F(e) = X$.*

Definition 2.5. *[8] The union of two amply soft sets $F * A$ and $G * B$ over a common universe X is the amply soft set $H * C$, where $C = A \cup B$ and for all $e \in E$,*

$$H(e) = \begin{cases} F(e), \forall e \in A - B \\ G(e), \forall e \in B - A \\ F(e) \cup G(e), \forall e \in A \cap B \\ \emptyset, \forall e \in E - C \end{cases}$$

We can write $(F * A) \mathrel{\tilde{\cup}} (G * B) \mathrel{\tilde{=}} (F \cup G) * (A \cup B) \mathrel{\tilde{=}} (H * C)$.

Definition 2.6. *[8] The intersection of two amply soft sets $F * A$ and $G * B$ over a common universe X is the amply soft set $H * C$, where $C = A \cap B$ and for all $e \in E$,*

$$H(e) = \begin{cases} F(e) \cap G(e), \forall e \in C \\ \emptyset, \forall e \in E - C \end{cases}$$

We can write $(F * A) \mathrel{\tilde{\cap}} (G * B) \mathrel{\tilde{=}} (F \cap G) * (A \cap B) \mathrel{\tilde{=}} (H * C)$.

Definition 2.7. *[8] The difference $H * A$ of two amply soft sets $F * A$ and $G * B$ over X denoted by $(F * A) \tilde{\setminus} (G * B)$ and it is defined as*

$$H(e) = \begin{cases} F(e), \ \forall e \in A - B \\ F(e) \setminus G(e), \ \forall e \in A \cap B \\ \emptyset, \forall e \in E - A \end{cases}$$

We can write $(F * A) \setminus (G * B) \tilde{=} (F \setminus G) * A \tilde{=} (H * A)$.

Definition 2.8. *[8] Let $F * A$ be an amply soft set X. The complement of an amply soft set $F * A$ over X is denoted by $(F * A)^{'} \tilde{=} F^{'} * E$ where $F^{'} : E \to P(X)$ a mapping is defined by $F^{'}(e) = X - F(e)$ for all $e \in A$.*

Definition 2.9. *[8] Let $F * E$ be an amply soft set over X and $x \in X$. We say that $x \tilde{\in} F * E$ read as amply soft point x belongs to the amply soft set $F * E$ if $x \in F(e)$ for all $e \in E$*

Definition 2.10. *An amply soft point $x \in X$ is called an amply limit point of $F * E$ iff every amply soft open set containing x, contains atleast one point of $F * E$, other than x. The set of all amply limit point point of $F * E$ is called the amply soft derived set of $F * E$ and is denoted as $(F * E)^{\tilde{d}}$.*

Definition 2.11. *[8]Let τ be the collection of amply soft sets over X, then $\tilde{\tau}$ is said to be an amply soft topology (or briefly AS topology) on X if,*

1. $\tilde{\emptyset}$, $\tilde{X}$ belong to $\tilde{\tau}$

2. The union of any number of amply soft sets in $\tilde{\tau}$ belongs to $\tilde{\tau}$.

3. The intersection of any two amply soft sets in $\tilde{\tau}$ belongs to $\tilde{\tau}$.

The triplet $(\tilde{X}, \tilde{\tau}, E)$ is called as an amply soft topological space over $\tilde{X}$. We will use AS topological space $\tilde{X}$ instead of amply soft topological space $(\tilde{X}, \tilde{\tau}, E)$ for shortly. The members of $\tilde{\tau}$ are said to be amply soft open sets in an amply soft topological space $\tilde{X}$. An amply soft set $F * A$ over X is said to be an amply soft closed set in an amply soft topological space $\tilde{X}$, if its complement $(F * A)^{'}$ belongs to $\tilde{\tau}$. The union of all amply soft open subsets of $F * A$ is an amply soft interior of $F * A$ denoted by $(F * A)^{\tilde{\circ}}$. And the intersection of all amply soft closed supersets of $F * A$ is an amply soft closure of $F * A$ denoted by $\overline{(F * A)}$. The collection $\tau_e = \{F(e) | \ (F * E) \tilde{\in} \tilde{\tau}\}$ for each $e \in E$, defines topologies on X.

3 Amply Soft Topological Spaces

Theorem 3.1. *The intersection of arbitrary collection of amply soft topologies for a common universe X is an amply soft topology over $\tilde{X}$.*

Proof. Let $\{(\tilde{X}, \ \tilde{\tau_\lambda}, \ E) : \lambda \in \Lambda\}$ be any family of amply soft topologies each defined over common universe X. It is clear that each $\tilde{\tau_\lambda}$ is coarser than the discrete amply soft topology. If $\Lambda = \emptyset$, then $\bigcap\{\tilde{\tau_\lambda} : \lambda \in \Lambda = \emptyset\}$ is a discrete amply soft topology. Let $\Lambda \neq \emptyset$

(1). $\tilde{\emptyset}$, $\tilde{X}$ belong to $\bigcap\{\tilde{\tau_\lambda} : \lambda \in \Lambda\}$

(2). If $\{(F_\alpha * E) : \alpha \in \Lambda_1\}$ is any family of amply soft sets in $\bigcap\{\tilde{\tau_\lambda} : \lambda \in \Lambda\}$, then $\bigcup\{(F_\alpha * E) : \alpha \in \Lambda_1\} \tilde{\in} \bigcap\{\tilde{\tau_\lambda} : \lambda \in \Lambda\}$.

(3). Let $F_1 * E$ and $F_2 * E$ are any two amply soft sets in $\bigcap\{\tilde{\tau_\lambda} : \lambda \in \Lambda\}$ then $(F_1 * E) \tilde{\cap} (F_2 * E) \tilde{\in} \tilde{\tau_\lambda}$ for each $\lambda \in \Lambda$ and hence $(F_1 * E) \tilde{\cap} (F_2 * E) \tilde{\in} \bigcap\{\tilde{\tau_\lambda} : \lambda \in \Lambda\}$.

Therefore $\bigcap\{\tilde{\tau_\lambda} : \lambda \in \Lambda\}$ is an amply soft topology over $\tilde{X}$.

Remark 3.2. *The union of two amply soft topologies for a common universe X is not necessarily an amply soft topology over X*

Example 3.3. *Let $X = \mathbb{R}$ be universal set and $E = \{e_1, e_2\}$ a parameter set. Let $\tilde{\tau_1}$ and $\tilde{\tau_2}$ be amply soft topologies defined as $\tilde{\tau_1} = \{\tilde{\emptyset}, \tilde{\mathbb{R}}, \{\mathbb{Q}_{\{e_1\}}, (1, 10)_{\{e_2\}}\}\}$ and $\tilde{\tau_2} = \{\tilde{\emptyset}, \tilde{\mathbb{R}}, \{\{\mathbb{R} - \mathbb{Q}\}_{\{e_1\}}, \{5\}_{\{e_2\}}\}\}$. Then $\tilde{\tau_1}$ and*

$\tilde{\tau_2}$ are amply soft topologies over X. But $\tilde{\tau_1} \cup \tilde{\tau_2} = \{\tilde{\emptyset}, \tilde{\mathbb{R}}, \{\mathbb{Q}_{\{e_1\}}, (1,10)_{\{e_2\}}\}, \{\{\mathbb{R}-\mathbb{Q}\}_{\{e_1\}}, \{5\}_{\{e_2\}}\}\}$ is not an amply soft topology, Since $\{\mathbb{Q}_{\{e_1\}}, (1,10)_{\{e_2\}}\} \cup \{\{\mathbb{R}-\mathbb{Q}\}_{\{e_1\}}, \{5\}_{\{e_2\}}\} = \{\mathbb{R}_{\{e_1\}}, (1,10)_{\{e_2\}}\}$ is not an amply soft open set in $\tilde{\tau_1} \cup \tilde{\tau_2}$.

Theorem 3.4. *Let $(\tilde{X}, \tilde{\tau}, E)$ be an amply soft topological space. Let $F * A$ be an amply soft set on X. Then $(F*A)\tilde{\cup}(F*A)^{\tilde{d}}$ is an amply soft closed set.*

Proof. To prove $(F*A)\tilde{\cup}(F*A)^{\tilde{d}}$ is an amply soft closed set it is enough to prove that $((F*A)\tilde{\cup}(F*A)^{\tilde{d}})^{\tilde{\prime}}$ is an amply soft open set. If $((F*A)\tilde{\cup}(F*A)^{\tilde{d}})^{\tilde{\prime}} \tilde{=} \tilde{\emptyset}$ then it is an amply soft open set. Let $((F*A)\tilde{\cup}(F*A)^{\tilde{d}})^{\tilde{\prime}} \tilde{\neq} \tilde{\emptyset}$ and $x \tilde{\in} ((F*A)\tilde{\cup}(F*A)^{\tilde{d}})^{\tilde{\prime}} \Rightarrow x \tilde{\notin} (F*A)\tilde{\cup}(F*A)^{\tilde{d}} \Rightarrow x \tilde{\notin} (F*A)$ and $x \tilde{\notin} (F*A)^{\tilde{d}}$. $x \tilde{\notin} (F*A) \Rightarrow \exists$ an amply soft open set $G*B \ni x \tilde{\in} (G*B)$ and $(G*B)\tilde{\cap}(F*A) \tilde{=} \tilde{\phi} \Rightarrow x\tilde{\in}(G*B) \tilde{\subseteq} (F*A)^{\tilde{\prime}}$. Again $x \tilde{\notin} (F*A)^{\tilde{d}} \Rightarrow x \tilde{\in} G*B \tilde{\subseteq} ((F*A)^{\tilde{d}})^{\tilde{\prime}}$. Therefore $x \tilde{\in}(G*B) \subseteq ((F*A)\tilde{\cup}(F*A)^{\tilde{d}})^{\tilde{\prime}}$ and hence $((F*A)\tilde{\cup}(F*A)^{\tilde{d}})^{\tilde{\prime}}$ is amply soft open set.

Theorem 3.5. *Let $(\tilde{X}, \tilde{\tau}, E)$ be an amply soft topological space and F*A be an amply soft set over X then $\overline{(F*A)} \tilde{=} (F*A)\tilde{\cup}(F*A)^{\tilde{d}}$.*

Proof. We know that $(F*A)\tilde{\cup}(F*A)^{\tilde{d}}$ is an amply soft closed set. So $(F*A)\tilde{\cup}(F*A)^{\tilde{d}}$ is an amply soft closed superset of $F*A$ and $\overline{(F*A)}$ is the smallest amply soft closed superset of $F*A$. Therefore $\overline{(F*A)}$ $\tilde{\subseteq}((F*A)\tilde{\cup}(F*A)^{\tilde{d}})$. Again $F*A \tilde{\subseteq} \overline{(F*A)} \Rightarrow (F*A)^{\tilde{d}} \tilde{\subseteq} (\overline{(F*A)})^{\tilde{d}} \tilde{\subseteq} \overline{(F*A)}$.
Thus$((F*A)\tilde{\cup}(F*A)^{\tilde{d}}) \tilde{\subseteq} \overline{(F*A)}$. Hence $\overline{(F*A)} \tilde{=}((F*A)\tilde{\cup}(F*A)^{\tilde{d}})$

Theorem 3.6. *Let $(\tilde{X}, \tilde{\tau}, E)$ be an amply soft topological space and $F*A$ be an amply soft set over X then $F*A$ is amply soft an closed iff $\overline{F*A} \tilde{=} F*A$*

Proof. If $F*A$ is an amply soft closed set then the smallest amply soft closed super set of $F*A$ is $F*A$ itself. Therefore $\overline{F*A} \tilde{=} F*A$. Converesely if $\overline{F*A} \tilde{=} F*A$ then $\overline{F*A}$ being closed so as $F*A$.

Theorem 3.7. *Let $(\tilde{X}, \tilde{\tau}, E)$ be an amply soft topological space and $F*A$, $G*B$ be amply soft sets over X then*

1. $\overline{\tilde{\emptyset}} \tilde{=} \tilde{\emptyset}, \overline{\tilde{X}} \tilde{=} \tilde{X}$ *and* $\overline{\left(\overline{(F*A)}\right)} \tilde{=} F*A$.
2. $F*A \tilde{\subseteq} G*B \Rightarrow \overline{F*A} \tilde{\subseteq} \overline{G*B}$.
3. $\overline{(F*A)\tilde{\cap}(G*B)} \tilde{\subseteq} (\overline{F*A})\tilde{\cap}(\overline{G*B})$.
4. $\overline{(F*A)\tilde{\cup}(G*B)} \tilde{=} (\overline{F*A})\tilde{\cup}(\overline{G*B})$.

Proof.

1. Obvious, since $\tilde{\emptyset}$, $\tilde{X}$ and $\overline{F*A}$ are amply soft closed sets.
2. $F*A \tilde{\subseteq} G*B \tilde{\subseteq} \overline{G*B}$ i.e,$\overline{G*B}$ is an amply soft closed superset of $F*A$. And $\overline{F*A}$. is the smallest amply soft closed superset of $F*A$. Therefore $\overline{F*A} \tilde{\subseteq} \overline{G*B}$.
3. $(F*A) \tilde{\cap} (G*B) \tilde{\subseteq} (F*A) \Rightarrow \overline{(F*A)\tilde{\cap}(G*B)} \tilde{\subseteq} \overline{(F*A)}$ and $(F*A) \tilde{\cap}(G*B) \tilde{\subseteq} (G*B) \Rightarrow \overline{(F*A) \tilde{\cap} (G*B)} \tilde{\subseteq} \overline{(G*B)}$. Therefore $\overline{(F*A)\tilde{\cap}(G*B)} \tilde{\subseteq} (\overline{F*A})\tilde{\cap}(\overline{G*B})$.

4. $F * A \,\tilde{\subseteq}\, (F * A)\tilde{\cup}(G * B) \Rightarrow \overline{(F * A)}\tilde{\subseteq}\overline{(F * A)\tilde{\cup}(G * B)}$ and $G * B \,\tilde{\subseteq}\, (F * A)\tilde{\cup}(G * B) \Rightarrow \overline{(G * B)}\tilde{\subseteq}\overline{(F * A)\tilde{\cup}(G * B)}$. On the other hand $F * A \,\tilde{\subseteq}\, \overline{F * A}$ and $G * B \,\tilde{\subseteq}\, \overline{G * B}$ implies $(F * A)\tilde{\cup}(G * B) \,\tilde{\subseteq}\, \overline{(F * A)}\tilde{\cup}\overline{(G * B)}$. Since $\overline{(F * A)}\tilde{\cup}\overline{(G * B)}$ is an amply soft closed set, $\overline{(F * A)\tilde{\cup}(G * B)} \,\tilde{\subseteq}\, \overline{(F * A)}\tilde{\cup}\overline{(G * B)}$. Therefore$\overline{(F * A)\tilde{\cup}(G * B)} \,\tilde{=}\, \overline{(F * A)}\tilde{\cup}\overline{(G * B)}$.

Theorem 3.8. *Let $(\tilde{X}, \tilde{\tau}, E)$ be an amply soft topological space and $F * A$ be an amply soft set over X then $F * A$ is amply soft open set iff $(F * A)^{\tilde{o}} = F * A$.*

Proof. Let $F * A$ be an amply soft open set. Then the largest amply soft subset of $F * A$ is $F * A$ itself. Therefore $(F * A)^{\tilde{o}} \tilde{=} F * A$. Conversely, Let $(F * A)^{\tilde{o}} \tilde{=} F * A$. Since $(F * A)^{\tilde{o}}$is amply soft open set so as$F * A$.

Theorem 3.9. *Let $(\tilde{X}, \tilde{\tau}, E)$ be an amply soft topological space and $F * A$,$G * B$ be amply soft sets over X then*

1. $(\tilde{\emptyset})^{\tilde{o}} \,\tilde{=}\, \tilde{\emptyset}$,$(\tilde{X})^{\tilde{o}} \,\tilde{=}\, \tilde{X}$ *and* $((F * A)^{\tilde{o}})^{\tilde{o}} \tilde{=} F * A$.
2. $F * A \,\tilde{\subseteq}\, G * B \Rightarrow (F * A)^{\tilde{o}} \,\tilde{\subseteq}\, (G * B)^{\tilde{o}}$.
3. $(F * A)^{\tilde{o}} \,\tilde{\cup}\, (G * B)^{\tilde{o}} \,\tilde{\subseteq}\, ((F * A) \,\tilde{\cup}\, (G * B))^{\tilde{o}}$.
4. $((F * A) \,\tilde{\cap}\, (G * B))^{\tilde{o}} \tilde{=} (F * A)^{\tilde{o}} \,\tilde{\cap}\, (G * B)^{\tilde{o}}$

Proof.

1. Obvious, since $\tilde{\emptyset}$, $\tilde{X}$ and $(F * A)^{\tilde{o}}$ are amply soft open sets.
2. Let $F * A \,\tilde{\subseteq}\, G * B$ and $x \in (F * A)^{\tilde{o}}$. Then $F * A$ is an amply soft nbd of x so as $G * B$ which implies x is an amply soft interior point of $G * B$ i.e, $x \in (G * B)^{\tilde{o}}$. Therefore $(F * A)^{\tilde{o}} \,\tilde{\subseteq}\, (G * B)^{\tilde{o}}$.
3. $(F * A) \,\tilde{\subseteq}\, (F * A) \,\tilde{\cup}\, (G * B) \Rightarrow (F * A)^{\tilde{o}} \,\tilde{\subseteq}\, ((F * A) \,\tilde{\cup}\, (G * B))^{\tilde{o}}$ and $(G * B) \,\tilde{\subseteq}\, (F * A) \,\tilde{\cup}\, (G * B) \Rightarrow (G * B)^{\tilde{o}} \,\tilde{\subseteq}\, ((F * A) \,\tilde{\cup}\, (G * B))^{\tilde{o}}$ implies $((F * A)^{\tilde{o}} \,\tilde{\cup}\, (G * B)^{\tilde{o}}) \,\tilde{\subseteq}\, ((F * A) \,\tilde{\cup}\, (G * B))^{\tilde{o}}$.
4. $((F * A) \,\tilde{\cap}\, (G * B)) \,\tilde{\subseteq}\, (F * A) \Rightarrow ((F * A) \,\tilde{\cap}\, (G * B))^{\tilde{o}} \,\tilde{\subseteq}\, (F * A)^{\tilde{o}}$ and $((F * A) \,\tilde{\cap} (G * B)) \,\tilde{\subseteq}\, (G * B) \Rightarrow ((F * A) \,\tilde{\cap}\, (G * B))^{\tilde{o}} \tilde{\subseteq}\, (G * B)^{\tilde{o}}$ implies $((F * A) \,\tilde{\cap}\, (G * B))^{\tilde{o}} \,\tilde{\subseteq}\, ((F * A)^{\tilde{o}} \,\tilde{\cap}\, (G * B)^{\tilde{o}})$. Again $(F * A)^{\tilde{o}} \,\tilde{\subseteq}\, (F * A)$ and $(G * B)^{\tilde{o}} \,\tilde{\subseteq} (G * B)$ implies $((F * A)^{\tilde{o}} \,\tilde{\cap} (G * B)^{\tilde{o}}) \,\tilde{\subseteq}\, ((F * A) \,\tilde{\cap}\, (G * B))$ implies $((F * A)^{\tilde{o}} \,\tilde{\cap}\, (G * B)^{\tilde{o}})^{\tilde{o}} \,\tilde{\subseteq}\, ((F * A) \,\tilde{\cap}\, (G * B))^{\tilde{o}}$. Since $((F * A)^{\tilde{o}} \tilde{\cap}\, (G * B)^{\tilde{o}}$ is amply soft open set $((F * A)^{\tilde{o}} \,\tilde{\cap} (G * B)^{\tilde{o}}) \tilde{=} ((F * A) \,\tilde{\cap}\, (G * B))^{\tilde{o}}$. Hence $((F * A) \,\tilde{\cap}\, (G * B))^{\tilde{o}} \tilde{=} (F * A)^{\tilde{o}} \,\tilde{\cap}\, (G * B)^{\tilde{o}}$.

Theorem 3.10. *Let $(\tilde{X}, \tilde{\tau}, E)$ be an amply soft topological space and $F * A$ be an amply soft set over X then$(F * A)^{\tilde{o}}$ is the set of all those point of $F * A$ which are not the amply soft limit point of $(F * A)^{\tilde{\prime}}$.*

Proof. Let $x \,\tilde{\in}\, F * A$ and x is not an amply soft limit point of $(F * A)^{\tilde{\prime}}$. Then $x \,\tilde{\notin}\, (F * A)^{\tilde{\prime}}$. So, there exist an amply soft open set $G * B$ such that $x \,\tilde{\in}\, G * B$ and $G * B$ is disjoint from $(F * A)^{\tilde{\prime}}$. i.e, $x \,\tilde{\in}\, G * B \,\tilde{\subseteq}\, F * A$. Therefore $x \,\tilde{\in}\, (F * A)^{\tilde{o}}$. Again let $x \,\tilde{\in}\, (F * A)^{\tilde{o}}$. Then $(F * A)^{\tilde{o}}$ is an amply soft open set containing x and not containing any point of $F * A$, which is not an amply soft limit point of $(F * A)^{\tilde{\prime}}$.

Theorem 3.11. *Let $(\tilde{X}, \tilde{\tau}, E)$ be an amply soft topological space and $F * A$ be an amply soft set over X, then*

1. $(F*A)^{\tilde{\circ}} \tilde{=} \{(\overline{(F*A)'})\}^{\tilde{\prime}}$.

2. $\overline{F*A} \tilde{=} \{((F*A)^{\tilde{\prime}})^{\tilde{\circ}}\}^{\tilde{\prime}}$.

Proof.

1. Since $(F*A)^{\tilde{\circ}}$ is the set of all those point of $F*A$ which are not the amply soft limit point of $(F*A)^{\tilde{\prime}}$. i.e, $(F*A)^{\tilde{\circ}} = (F*A) \tilde{\cap} \{((F*A)^{\tilde{\prime}})'\}^{\tilde{\prime}}$. Taking complements and using De-morgans law,$(F*A)^{\tilde{\circ}} \tilde{=} \{(\overline{(F*A)'})\}^{\tilde{\prime}}$.

2. Replacing $F*A$ by $(F*A)^{\tilde{\prime}}$ and taking complements in the above result $\overline{F*A} \tilde{=} \{((F*A)^{\tilde{\prime}})^{\tilde{\circ}}\}^{\tilde{\prime}}$.

4 Amply Soft Exterior

Definition 4.1. *Let $(\tilde{X}, \tilde{\tau}, E)$ be an AS topological space and $F*A$ be an amply soft set over $\tilde{X}$. Then the amply soft exterior of $F*A$ denoted by $(F*A)^{\tilde{e}}$ is $\left((F*A)^{\tilde{\prime}}\right)^{\tilde{\circ}}$.*

Example 4.2. *Let $X = (1, 10)$ be universal set and $E = \{e_1, e_2\}$ a parameter set.*
Let $\tilde{\tau} = \left\{\tilde{\phi}, \tilde{X}, \left\{[1,2]_{\{e_1\}}, [4,5]_{\{e_2\}}\right\}, \left\{(0,3]_{\{e_1\}}, [2,7]_{\{e_2\}}\right\}\right\}$ be an amply soft topology. Consider an amply soft set $F*A = \left\{(3,5)_{\{e_1\}}, (4,5)_{\{e_2\}}\right\}$. Then $(F*A)^{\tilde{e}}$ is $\left\{(0,3)_{\{e_1\}}, [2,7]_{\{e_2\}}\right\}$

Theorem 4.3. *Let $(\tilde{X}, \tilde{\tau}, E)$ be an AS topological space and $F*A$,$G*B$ be AS sets over $\tilde{X}$ then*

1. $\left(\tilde{\phi}\right)^{\tilde{e}} \tilde{=} \tilde{X}; \left(\tilde{X}\right)^{\tilde{e}} \tilde{=} \tilde{\phi}$

2. $(F*A)^{\tilde{e}} \tilde{\subseteq} (F*A)^{\tilde{\prime}}$

3. $(F*A)^{\tilde{e}} \tilde{=} \left(\left((F*A)^{\tilde{e}}\right)^{\tilde{\prime}}\right)^{\tilde{e}}$

4. $F*A \tilde{\subseteq} G*B \Rightarrow (G*B)^{\tilde{e}} \tilde{\subseteq} (F*A)^{\tilde{e}}$

5. $(F*A)^{\tilde{\circ}} \tilde{\subseteq} \left((F*A)^{\tilde{e}}\right)^{\tilde{e}}$

6. $(((F*A) \tilde{\cup} (G*B)))^{\tilde{e}} \tilde{=} (F*A)^{\tilde{e}} \tilde{\cap} (G*B)^{\tilde{e}}$

Proof.

1. $\left(\tilde{\phi}\right)^{\tilde{e}} \tilde{=} \left(\left(\tilde{\phi}^{\tilde{\prime}}\right)^{\tilde{\circ}}\right) \tilde{=} \tilde{X}$; $\left(\tilde{X}\right)^{\tilde{e}} \tilde{=} \left(\left(\tilde{X}^{\tilde{\prime}}\right)^{\tilde{\circ}}\right) \tilde{=} \tilde{\phi}$

2. $(F*A)^{\tilde{e}} \tilde{=} \left((F*A)^{\tilde{\prime}}\right)^{\tilde{\circ}} \tilde{\subseteq} (F*A)^{\tilde{\prime}}$

3. $\left(\left((F*A)^{\tilde{e}}\right)^{\tilde{\prime}}\right)^{\tilde{e}} \tilde{=} \left(\left(\left((F*A)^{\tilde{\prime}}\right)^{\tilde{\circ}}\right)^{\tilde{\prime}}\right)^{\tilde{e}} = \overline{(F*A)}^{\tilde{e}} \tilde{=} (F*A)^{\tilde{e}}$

4. $F * A \,\tilde{\subseteq}\, G * B \Rightarrow \ (G * B)^{\tilde{\prime}} \ \tilde{\subseteq} \ (F * A)^{\tilde{\prime}} \Rightarrow \ \left((G * B)^{\tilde{\prime}}\right)^{\tilde{\circ}} \ \tilde{\subseteq} \ \left((F * A)^{\tilde{\prime}}\right)^{\tilde{\circ}} \Rightarrow \ (G * B)^{\tilde{e}} \ \tilde{\subseteq} \ (F * A)^{\tilde{e}}$

5. $(F * A)^{\tilde{e}} \,\tilde{\subseteq}\, (F * A)^{\tilde{\prime}} \Rightarrow \ \left((F * A)^{\tilde{\prime}}\right)^{\tilde{e}} \ \tilde{\subseteq} \ \left((F * A)^{\tilde{e}}\right)^{\tilde{e}} \Rightarrow \ (F * A)^{\tilde{\circ}} \ \tilde{\subseteq} \ \left((F * A)^{\tilde{e}}\right)^{\tilde{e}}$

6. $((F * A) \,\tilde{\cup}\, (G * B))^{\tilde{e}} \,\tilde{=}\, \left(((F * A) \,\tilde{\cup}\, (G * B))^{\tilde{\prime}}\right)^{\tilde{\circ}} \,\tilde{=}\, (F * A)^{\tilde{e}} \,\tilde{\cap}\, (G * B)^{\tilde{e}}$

5 Boundary of an Amply Soft Set

Definition 5.1. *Let $(\tilde{X}, \tilde{\tau}, E)$ be an amply soft topological space and $F * A$ be an amply soft set over $\tilde{X}$. A point $x \in X$ is called amply soft boundary point of $F * A$ if every amply soft open set containing x intersects both $F * A$ and $(F * A)^{\tilde{\prime}}$. The set of all amply soft boundary points of $F * A$ is called amply soft boundary of $F * A$ denoted by $(F * A)^{\tilde{b}}$.*

Example 5.2. *Let $X = (1, 10)$ be universal set and $E = \{e_1, e_2\}$ a parameter set.*
Let $\tilde{\tau} = \left\{\tilde{\phi}, \tilde{X}, \left\{[1,2]_{\{e_1\}}, [4,5]_{\{e_2\}}\right\}, \left\{(0,3]_{\{e_1\}}, [2,7]_{\{e_2\}}\right\}\right\}$ be an amply soft topology. Consider an amply soft set $F * A = \left\{(3,5)_{\{e_1\}}, (4,5)_{\{e_2\}}\right\}$. Then $(F * A)^{\tilde{b}}$ is $\left\{(3,10)_{\{e_1\}}, \{(0,2) \cup (7,10)\}_{\{e_2\}}\right\}$

Theorem 5.3. *Let $(\tilde{X}, \tilde{\tau}, E)$ be an AS topological space and $F * A$ be an amply soft set over $\tilde{X}$. Then $(F * A)^{\tilde{b}} = \overline{F * A} \,\tilde{\cap}\, \overline{(F * A)^{\tilde{\prime}}}$.*

Proof. Let $x \in (F * A)^{\tilde{b}} \Leftrightarrow$ every open set containing x intersects both $F * A$ and $(F * A)^{\tilde{\prime}} \Leftrightarrow$ neither $F * A$ nor $(F * A)^{\tilde{\prime}}$ is an amply soft nbd of $x \Leftrightarrow x \notin (F * A)^{\tilde{\circ}}$ and $x \notin \left((F * A)^{\tilde{\prime}}\right)^{\tilde{\circ}} \Leftrightarrow x \in \left((F * A)^{\tilde{\circ}}\right)^{\tilde{\prime}}$ and $\left\{\left((F * A)^{\tilde{\prime}}\right)^{\tilde{\circ}}\right\}^{\tilde{\prime}}$. Therefore $(F * A)^{\tilde{b}} = \overline{F * A} \,\tilde{\cap}\, \overline{(F * A)^{\tilde{\prime}}}$

Corollary 5.4. $(F * A)^{\tilde{b}} = \left((F * A)^{\tilde{\prime}}\right)^{\tilde{b}}$

Theorem 5.5. *Let $(\tilde{X}, \tilde{\tau}, E)$ be an AS topological space and $F * A$ be an amply soft set over $\tilde{X}$. Then $(F * A)^{\tilde{\circ}}$, $(F * A)^{\tilde{e}}$ and $(F * A)^{\tilde{b}}$ are mutually disjoint and $X = (F * A)^{\tilde{\circ}} \,\tilde{\cup}\, (F * A)^{\tilde{e}} \,\tilde{\cup}\, (F * A)^{\tilde{b}}$.*

Proof. $(F * A)^{\tilde{b}} \,\tilde{=}\, \overline{(F * A)} \,\tilde{\cap}\, \overline{(F * A)^{\tilde{\prime}}}$

$$\tilde{=} \left[\left(\overline{F * A}\right)^{\tilde{\prime}} \,\tilde{\cup}\, \left(\overline{(F * A)^{\tilde{\prime}}}\right)^{\tilde{\prime}}\right]^{\tilde{\prime}}$$

$$\tilde{=} \left[\left((F * A)^{\tilde{\prime}}\right)^{\tilde{\circ}} \,\tilde{\cup}\, (F * A)^{\tilde{\circ}}\right]^{\tilde{\prime}}$$

$$\tilde{=} \left[(F * A)^{\tilde{e}} \,\tilde{\cup}\, (F * A)^{\tilde{\circ}}\right]^{\tilde{\prime}}.$$

Therefore $\tilde{X} \,\tilde{=}\, (F * A)^{\tilde{b}} \,\tilde{\cup}\, \left((F * A)^{\tilde{b}}\right)^{\tilde{\prime}}$

$\Rightarrow \tilde{X} = (F * A)^{\tilde{b}} \,\tilde{\cup}\, (F * A)^{\tilde{e}} \,\tilde{\cup}\, (F * A)^{\tilde{\circ}}$.

Clearly $(F*A)^{\tilde{b}}\,\tilde{\cap}\,(F*A)^{\tilde{\circ}} \tilde{=} \tilde{\emptyset}$ and
$(F*A)^{\tilde{b}}\,\tilde{\cap}\,(F*A)^{\tilde{e}} \tilde{=} \tilde{\emptyset}$.
More over $(F*A)^{\tilde{\circ}}\,\tilde{\cap}\,(F*A)^{\tilde{e}}$
$\tilde{=} (F*A)^{\tilde{\circ}}\tilde{\cap}\left((F*A)^{\tilde{\prime}}\right)^{\tilde{\circ}}$
$\tilde{\subset}(F*A)\tilde{\cap}(F*A)^{\tilde{\prime}}$
$\tilde{=}\tilde{\emptyset}$.

Theorem 5.6. *Let $(\tilde{X}, \tilde{\tau}, E)$ be an amply soft topological space and $F*A$ be an amply soft set over $\tilde{X}$. Then*

1. $(F*A)^{\tilde{b}}$ *is an amply closed set.*
2. $\tilde{\emptyset}^{\tilde{b}} \tilde{=} \tilde{X}^{\tilde{b}} \tilde{=} \tilde{\emptyset}$
3. $\left((F*A)^{\tilde{b}}\right)^{\tilde{b}} \tilde{\subseteq} (F*A)^{\tilde{b}}$
4. $(F*A)^{\tilde{b}} \tilde{=} \overline{F*A} \,\tilde{\setminus}\, (F*A)^{\tilde{\circ}}$
5. $(F*A)^{\tilde{\circ}} \tilde{=} (F*A)\tilde{\setminus}\,(F*A)^{\tilde{b}}$
6. $\left((F*A)^{\tilde{\circ}}\right)^{\tilde{b}} \tilde{\subseteq} (F*A)^{\tilde{b}}$ *and* $\left(\overline{F*A}\right)^{\tilde{b}} \tilde{\subseteq} (F*A)^{\tilde{b}}$
7. $\overline{F*A} \tilde{=} (F*A)\tilde{\cup}(F*A)^{\tilde{b}} \tilde{=} (F*A)^{\tilde{\circ}}\tilde{\cup}(F*A)^{\tilde{b}}$

Proof.
1. From Theorem 5.3 $(F*A)^{\tilde{b}}$ is the intersection of two amply soft closed sets and so it is also amply soft closed set.
2. obvious
3. obvious from the definition of $(F*A)^{\tilde{b}}$.
4. $(F*A)^{\tilde{b}} \tilde{=} \overline{F*A}\tilde{\cap}\overline{(F*A)^{\tilde{\prime}}}$
$\tilde{=}\overline{F*A}\,\tilde{\setminus}\left(\overline{(F*A)^{\tilde{\prime}}}\right)^{\tilde{\prime}}$
$\tilde{=}\overline{F*A}\,\tilde{\setminus}(F*A)^{\tilde{\circ}}$.
5. $(F*A)\,\tilde{\setminus}\,(F*A)^{\tilde{b}} \tilde{=} (F*A)\,\tilde{\setminus}\,\left(\overline{(F*A)}\tilde{\cap}\overline{(F*A)^{\tilde{\prime}}}\right)$
$\tilde{=}(F*A)\,\tilde{\cap}\,\left(\overline{(F*A)}\tilde{\cap}\overline{(F*A)^{\tilde{\prime}}}\right)^{\tilde{\prime}}$
$\tilde{=}(F*A)\,\tilde{\cap}\,\left(\left((F*A)^{\tilde{\prime}}\right)^{\tilde{\circ}}\tilde{\cup}(F*A)^{\tilde{\circ}}\right)$
$\tilde{=}(F*A)^{\tilde{\circ}}$.
6. $\left((F*A)^{\tilde{\circ}}\right)^{\tilde{b}} \tilde{=} \overline{(F*A)^{\tilde{\circ}}}\,\tilde{\cap}\overline{\left((F*A)^{\tilde{\circ}}\right)^{\tilde{\prime}}}$
$\tilde{\subseteq}\overline{F*A}\tilde{\cap}\overline{\overline{(F*A)^{\tilde{\prime}}}}$
$\tilde{=}\overline{F*A}\tilde{\cap}\overline{(F*A)^{\tilde{\prime}}}$

$\tilde{=}(F*A)^{\tilde{b}}$ and
$(\overline{F*A})^{\tilde{b}}\tilde{=}\overline{\overline{F*A}}\tilde{\cap}\overline{(\overline{F*A})^{\tilde{\prime}}}$
$\tilde{\subseteq}\overline{F*A}\tilde{\cap}\overline{(F*A)^{\tilde{\prime}}}$
$\tilde{=}(F*A)^{\tilde{b}}$.

7. $(F*A)\,\tilde{\cup}\,(F*A)^{\tilde{b}}\tilde{=}(F*A)\,\tilde{\cup}\left(\overline{F*A}\tilde{\cap}\overline{(F*A)^{\tilde{\prime}}}\right)$
$\tilde{=}\left((F*A)^{\tilde{\circ}}\tilde{\cup}\overline{F*A}\right)\tilde{\cap}\left((F*A)^{\tilde{\circ}}\tilde{\cup}\overline{(F*A)^{\tilde{\prime}}}\right)$
$\tilde{=}\overline{F*A}\tilde{\cap}\left((F*A)^{\tilde{\circ}}\,\tilde{\cup}\left((F*A)^{\tilde{\circ}}\right)^{\tilde{\prime}}\right)$
$\tilde{=}\overline{F*A}\tilde{\cap}\tilde{X}$
$\tilde{=}\overline{F*A}$.

Theorem 5.7. *Let $(\tilde{X},\tilde{\tau},E)$ be an amply soft topological space and $F*A$ be an amply soft set over $\tilde{X}$. Then*

1. *$(F*A)$ is an amply soft open if and only if $(F*A)\,\tilde{\cap}\,(F*A)^{\tilde{b}}\tilde{=}\tilde{\emptyset}$*
2. *$(F*A)$ is an amply soft closed if and only if $(F*A)^{\tilde{b}}\tilde{\subseteq}F*A$*
3. *$(F*A)$ is an amply soft clopen if and only if $(F*A)^{\tilde{b}}\tilde{=}\tilde{\emptyset}$*

Proof. 1. Let $(F*A)$ is an amply soft open set. Then $(F*A)^{\tilde{\prime}}$ is an amply soft closed set. $\overline{(F*A)^{\tilde{\prime}}}\tilde{=}(F*A)^{\tilde{\prime}}$. Consequently $(F*A)\,\tilde{\cap}\,(F*A)^{\tilde{b}}\tilde{=}(F*A)\,\tilde{\cap}\left(\overline{F*A}\tilde{\cap}\overline{(F*A)^{\tilde{\prime}}}\right)\tilde{=}\tilde{\emptyset}$. Conversely, let $(F*A)\,\tilde{\cap}\,(F*A)^{\tilde{b}}=\tilde{\emptyset}$. Then $(F*A)\,\tilde{\cap}\left(\overline{F*A}\tilde{\cap}\overline{(F*A)^{\tilde{\prime}}}\right)\tilde{=}\tilde{\emptyset}$.

$(F*A)\,\tilde{\cap}\overline{(F*A)^{\tilde{\prime}}}\tilde{=}\tilde{\emptyset}$
$(F*A)\,\tilde{\subseteq}\left(\overline{(F*A)^{\tilde{\prime}}}\right)^{\tilde{\prime}}\tilde{=}(F*A)^{\tilde{\circ}}$.

Thus $(F*A)\,\tilde{\subseteq}\,(F*A)^{\tilde{\circ}}$ but $(F*A)^{\tilde{\circ}}\,\tilde{\subseteq}F*A$. Therefore $F*A$ ia an amply soft set.

2. Let $(F*A)$ be an amply soft closed set.
Then $\overline{(F*A)}=(F*A)$. $(F*A)^{\tilde{b}}\tilde{=}\overline{(F*A)}\tilde{\cap}\overline{(F*A)^{\tilde{\prime}}}$
$\tilde{=}(F*A)\,\tilde{\cap}\overline{(F*A)^{\tilde{\prime}}}\tilde{\subseteq}(F*A)$.
Conversely $(F*A)^{\tilde{b}}\tilde{\subseteq}(F*A)$ and therefore $(F*A)\,\tilde{\cup}\,(F*A)^{\tilde{b}}\tilde{=}(F*A)$ but $(F*A)\,\tilde{\cup}\,(F*A)^{\tilde{b}}\tilde{=}\overline{(F*A)}$. Therefore $\overline{(F*A)}\tilde{=}(F*A)$. Hence $(F*A)$ is an amply soft closed set.

3. Let $(F*A)$ be an amply soft clopen set. Then $(F*A)$ and $(F*A)^{\tilde{\prime}}$ are amply soft closed set. i.e., $\overline{F*A}\tilde{=}F*A$ and $\overline{(F*A)^{\tilde{\prime}}}\tilde{=}(F*A)^{\tilde{\prime}}$. Therefore $(F*A)^{\tilde{b}}\tilde{=}\overline{F*A}\tilde{\cap}\overline{(F*A)^{\tilde{\prime}}}\tilde{=}\tilde{\emptyset}$
Conversely let $(F*A)^{\tilde{b}}\tilde{=}\tilde{\emptyset}$
$\overline{(F*A)}\,\tilde{\setminus}\,(F*A)^{\tilde{\circ}}\tilde{=}\tilde{\emptyset}$
$\overline{(F*A)}\tilde{\subseteq}(F*A)^{\tilde{\circ}}\tilde{\subseteq}(F*A)$
$(F*A)\,\tilde{\cup}\,(F*A)^{\tilde{b}}\tilde{\subseteq}(F*A)^{\tilde{\circ}}$

$(F*A)\,\tilde{\subseteq}\,(F*A)^{\circ}$

From (1) and (2) $(F*A)$ is both amply soft open and closed. Therefore $(F*A)$ is amply soft clopen.

Theorem 5.8. *Let $(\tilde{X},\tilde{\tau},E)$ be an amply soft topological space, $F*A$ and $F*B$ be the amply soft sets over $\tilde{X}$. Then*

1. $((F*A)\,\tilde{\cup}\,(F*B))^{\tilde{b}}\,\tilde{\subseteq}(F*A)^{\tilde{b}}\,\tilde{\cup}\,(F*B)^{\tilde{b}}$

2. $((F*A)\,\tilde{\cap}\,(F*B))^{\tilde{b}}\,\tilde{\subseteq}(F*A)^{\tilde{b}}\,\tilde{\cap}\,(F*B)^{\tilde{b}}$

Proof. 1. $((F*A)\,\tilde{\cup}\,(F*B))^{\tilde{b}}\,\tilde{=}\left(\overline{(F*A)\,\tilde{\cup}\,(G*B)}\right)\tilde{\cap}\overline{((F*A)\,\tilde{\cup}\,(G*B))^{\tilde{\prime}}}$

$\tilde{\subseteq}\left(\overline{(F*A)\,\tilde{\cup}\,(G*B)}\right)\tilde{\cap}\overline{(F*A)^{\tilde{\prime}}}\tilde{\cap}\overline{(G*B)^{\tilde{\prime}}}$

$\tilde{=}\left[\overline{(F*A)}\tilde{\cap}\overline{(F*A)^{\tilde{\prime}}}\tilde{\cup}\overline{(G*B)}\tilde{\cap}\overline{(F*A)^{\tilde{\prime}}}\right]\tilde{\cap}\overline{(G*B)^{\tilde{\prime}}}$

$\tilde{=}\left((F*A)^{\tilde{b}}\,\tilde{\cap}\overline{(G*B)^{\tilde{\prime}}}\right)\tilde{\cup}\left((G*B)^{\tilde{b}}\,\tilde{\cap}\overline{(F*A)^{\tilde{\prime}}}\right)$

$\tilde{\subseteq}\,(F*A)^{\tilde{b}}\,\tilde{\cup}\,(G*B)^{\tilde{b}}$

2. $((F*A)\,\tilde{\cap}\,(F*B))^{\tilde{b}}\,\tilde{=}\overline{(F*A)\,\tilde{\cap}\,(G*B)}\tilde{\cap}\left[\overline{((F*A)\,\tilde{\cap}\,(G*B))^{\tilde{\prime}}}\right]$

$\tilde{\subseteq}\left(\overline{(F*A)}\tilde{\cap}\overline{(G*B)}\right)\tilde{\cap}\left(\overline{(F*A)^{\tilde{\prime}}}\tilde{\cap}\overline{(G*B)^{\tilde{\prime}}}\right)$

$\tilde{=}\left[\overline{(F*A)}\tilde{\cap}\overline{(G*B)}\tilde{\cap}\overline{\left((F*A)^{\tilde{\prime}}\right)}\right]\tilde{\cup}\left[\overline{F*A}\tilde{\cap}\overline{G*B}\tilde{\cap}G*B\right]$

$\tilde{=}\left[(F*A)^{\tilde{b}}\,\tilde{\cap}\overline{G*B}\right]\tilde{\cup}\left[\overline{F*A}\tilde{\cap}\,(G*B)^{\tilde{b}}\right]$

$\tilde{\subseteq}(F*A)^{\tilde{b}}\,\tilde{\cap}\,(F*B)^{\tilde{b}}$

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