

Domains Formation Mediated by Electromagnetic Fields in Very Dilute Aqueous Solutions:

2. Quantum Electrodynamic Analyses of Experimental Data on Strong Electrolyte Solutions

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For a list of abbreviations, see **Table 1** on page 65.

(This is the second part of a three-part series.)

Abstract

Molecular associates in aqueous solutions of strong electrolytes are analyzed. The solutions' concentrations (C) were in the range of $2 \cdot 10^{-20}$ M. Preparation of the solutions involved serial dilutions of a stock solution and vigorous shaking after each dilution step. Electromagnetic fields were observed to mediate formation of some associate types. Screening ambient electromagnetic fields by placing the solutions in Permalloy containers destroyed these associates. Therefore we carry out our analyses with a model explicitly describing electrodynamic interactions. Our analyses show: (i) The 10^{-7} - 10^{-4} m sized associates observed by light scattering, atomic force microscopy and other techniques, have the typical characteristics predicted by the model. (ii) Electromagnetic fields mediate formation of: (a) 10^{-5} - 10^{-4} m sized associates mainly composed of ferroelectric ordered water molecules, present at solute dependent C

ranges (typically $C < 10^{-7}$ M); (b) 10^{-7} m sized associates composed of electronically excited water molecules. (iii) The prerequisites of serial dilutions and vigorous shaking for stabilizing associates at $C < 10^{-7}$ M are clarified.

Introduction

During the last two decades, water molecules (H_2O) and solvated strong electrolytes associating spontaneously in aqueous solutions unambiguously have been observed by light scattering and electron microscopy (Lo, 1996a; Li and Ogawa, 2000; Georgalis *et al.*, 2000; Samal and Geckeler, 2001; Sedlak, 2006; Ryzhkina *et al.*, 2012). The molecular association is not due to nanobubbles (Sedlak and Rak, 2013). These are 10^{-7} - 10^{-4} m sized groupings consisting of numerous H_2O and some solvated ions. The research group of Konovalov was the first to discover that ambient electromagnetic fields (EMF) affect the groupings (Ryzhkina *et al.*, 2012; for review see Konovalov and Ryzhkina, 2014). They showed that storing

samples of aqueous NaCl under hypo electromagnetic conditions, *i.e.*, in a Permalloy container with residual field of 10 nano Tesla, affect prevalence of the various types of groupings and their impact on electric conductivity.

Elia and Niccoli (1999, 2000, 2004a) with calorimetric, electric conductivity and pH measurements were the first to reveal supramolecular orderings in solutions prepared by up to 30 times serial centesimal diluting a 1% weight/volume stock aqueous NaCl solution (for review see Elia and Germano, 2015). They showed that whenever at each centesimal dilution step the samples are not vigorously succussed, these do not contain such orderings for C below a critical concentration (C_{crit}); typically $10^{-8} \text{ M} < C_{crit} < 10^{-6} \text{ M}$. Stabilization of the molecular groupings occurs during about 1-18 hours after preparation of the serial diluted vigorous shaken aqueous strong electrolyte solution (SDVSASES).^a

Impurities released by containers affect SDVSASES but cannot account for their typical properties. Elia and Niccoli (2004a, 2004b) used dark glass as well as laboratory glass

^a SDVSASES preparation involves serial decimal or centesimal diluting a “stock” solution. SDVSASES are prepared with freshly doubly distilled water or water purified by Simplicity® Water Purification Systems - Millipore. The electrical conductivity of these waters is below $1.5 \mu\text{S}/\text{cm}$. Dust is removed. The stock solution is analyzed for absence of impurities. C of stock solutions are in the $4 \text{ M} - 10^{-3} \text{ M}$ range. After each dilution step, SDVSASES are vigorously shaken, *e.g.*, with lab dancer shaker, by vertical vortexing or other methods. Plastic or glass vessels are used. Temperature and pressure are kept constant, typically, respectively, at 298 K and about 1 atmosphere. As controls, water is serially diluted and shaken after each dilution step, with all experimental parameters identical to those of SDVSASES preparation.

bottles. The former but not the latter release significant amounts of alkaline oxide and silica. They showed for SDVSASES of NaCl with C below about 10^{-8} M their heat of mixing with NaOH and their electric conductivity differ from the controls, *i.e.*, from solutions with equivalent chemical composition prepared without vigorous shaking. Konovalov, Ryzhkina and co-workers [Arbuzov Institute at Kazan Scientific Center -- Russian Federation (private discussions)] observed electric conductivity is higher for $10^{-20} \text{ M} < C < 10^{-2} \text{ M}$ SDVSASES prepared with glass utensils than with plastic ones. However, the typical features (*e.g.*, extrema) in SDVSASES electric conductivity's dependence on concentration are similar. The similarity indicates that impurities released by glass utensils affect these liquids' physicochemical variables' value (*e.g.*, raise electric conductivity) but do not alter their associate types.

Ambient EMF majorly affecting selforganization of molecules in SDVSASES indicates explaining their properties necessitates electrodynamic theory. The quantum electrodynamic (QED) model for SDVSASES proposed by Yinnon and Yinnon (2011) has provided consistent explanations for various phenomena, *e.g.*, SDVSASES' electric conductivity, heat of mixing and their dependence on time and volume (Yinnon and Elia, 2013).

The original lack of insight into the nature of the molecular associates, *e.g.*, the forces underlying their formation and their sizes, instigated labeling these as supramolecular orderings, clusters, nano-associates or nano-particles. Their recent unveiled properties render these terms inappropriate.^b In

^b According to the customary chemical nomenclature, supramolecular orderings refer to definite structures wherein electro-static interactions ‘glue’ the molecules together, with EMF not known to play significant roles. Clusters typically refer to small groupings consisting

particular because of ultraviolet (UV), visible or Infra Red (IR) EMF mediating attraction between 10^{-7} or $10^{-4} - 10^{-5}$ m distanced molecules in the associates, we propose designating these “domains” - a term concurrent with that used by the physicist who predicted their existence.^c

Our goals are:

a) Employing the QED model for SDVSASES for explaining recently observed (and to the best of our knowledge yet unexplained) characteristics of the various domain types present in these liquids.

b) Elucidating the domains’ impacts on some of these liquids’ properties, *e.g.*, their spectra and electric conductivities. These elucidations complement earlier ones reported in Yinnon and Yinnon (2011) and Yinnon and Elia (2013).

The outline of the paper is as follows: firstly, in the Theory section we concisely summarize the SDVSASES model. Next in the Discussion section, we show that recently measured properties of SDVSASES conform to those predicted by the model. Since QED of aqueous solutions hitherto mainly has been employed for explaining special phenom-

na, many readers may be unfamiliar with it. Therefore, its aspects relevant to our analyses we concisely summarized in the paper preceding this one in this journal’s issue (Yinnon and Liu, 2015a). We stress we do not present any new experimental results -- our analyses pertain to previous reported experimental data. A list with abbreviations is presented at the end of this paper. As to the importance of our goals, SDVSASES have implications for numerous technologies.

Theory

Customary models of aqueous strong electrolyte solutions predict: EMF, serial dilutions or vigorous shaking do not affect their characteristics; solvated solutes distribute homogeneously, move independently and randomly; H_2O (except solvation shells’ H_2O) move randomly and form flickering hydrogen-bond networks (Horne, 1971; Robinson and Stokes, 2002). These customary models explicitly describe electrostatic forces and *assume electrodynamic ones can be treated perturbatively*. However, QED models *explicitly* including electrodynamic forces show EMF interactions with H_2O or with ions, for solute type dependent C ranges, may lead to formation of various QED domain types (Del Giudice, 1988, 1998, 2000; Arani *et al.*, 1995; Preparata, 1995 chapters 2, 5, 10; Yinnon and Yinnon, 2012). Based on formal QED theory descriptions of aqueous systems, the conditions for formation of these domains and their properties were *ab initio* derived.

These domains were generally labeled “CD” - a shortening for “coherence domains” [see Yinnon and Liu (2015a) for explanation of this labeling]. CD may agglomerate into supra-domains (supra-CD). Supra-CD are not ensembles of molecules but agglomerates of domains, like domains in liquid crystals.

Coherence Domains -- The various QED domain types hitherto identified, which are

of up to a few hundred molecules. The 10^{-7} m groupings indeed are very large nano-groupings, but it is more appropriate to denote the $10^{-6} - 10^{-5}$ m ones as ‘micro-groupings’.

^c Del Giudice *et al.* (1988, 2000), Preparata (1995 Chapters 1-3,5,10) and Arani *et al.* (1995) with QED identified several instabilities in water and its solutions, which may lead to liquid-liquid phase transitions. Interactions between EMF and matter fields may cause $10^6 - 10^{18}$ H_2O together with few solutes to organize in domains wherein the photons mediating their attractions are condensed. The domains’ characteristics conform to those of aqueous solutions’ 10^{-7} - 10^{-4} m groupings (Yinnon and Yinnon, 2009, 2011, 2012; Yinnon and Elia, 2013).

in detail described and schematically pictured by Yinnon and Liu (2015a), include:

- CD_{rot} -- these domains are composed of ferroelectric ordered H_2O . These H_2O coherently oscillate between two rotational states. CD_{rot} formation results from the dipole moments of their H_2O interacting with IR EMF. CD_{rot} have an electric dipole moment due to the ferroelectric ordering of their H_2O . In bulk water at ambient conditions, CD_{rot} do not auto-organize. However, immersing objects with sizable asymmetric charge distributions (*e.g.*, macromolecules, hydrophilic membranes) may induce their formation. Their presence induces a permanent time dependent polarization. Solutes are pulled into CD_{rot} . Few solute particles can locate in CD_{rot} and do not wreck their host. Many solute molecules destroy CD_{rot} . Solute type determines critical C below which CD_{rot} persist ($C_{crit}^{CD_{rot}}$). CD_{rot} 's diameter is of the order of $\sim 10^{-4} - 10^{-5}$ m.

- CD_{plasma} -- these domains are composed of few solvated ions and numerous H_2O . The plasma oscillations of these ions are coherent. Interactions between the ions and tetra Herz to mega Herz EMF underlie the coherence. CD_{plasma} are very stable domains. Energy gained by an ion on its incorporation in CD_{plasma} amounts to a few eV. In aqueous strong electrolyte solutions, CD_{plasma} form at all concentrations above the transition concentration $C_{trans}^{IPD_{plasma}}$. [This is not the case for aqueous solutions of weak electrolytes, as discussed in the subsequent paper (Yinnon and Liu, 2015b).] $C_{trans}^{IPD_{plasma}}$ is the concentration at which the distance between identical nearest neighbor ions equals the Debye length.^d For monovalent electrolytes $C_{trans}^{IPD_{plasma}} = 2.1 \times 10^{-4}$ M (Yinnon and Yinnon, 2012). The diameter of CD_{plasma} is of the order of 10^{-6} m. It is an inverse function of

concentration, *i.e.*, when the concentration decreases the size of CD_{plasma} increases, the number of its solvated solutes diminishes and the number of its H_2O enhances.

- IPD_{plasma} -- these domains are composed of few solvated ions and numerous H_2O . The plasma oscillations of these ions are in phase *i.e.*, an IPD_{plasma} is a special CD -- an In-Phase Domain. Also the plasma oscillations of their H_2O are in phase. Interactions between its molecules and tetra Herz to mega Herz EMF underlie all these in phase plasma oscillations. IPD_{plasma} are crystalline structured. The dipole moments of their H_2O are spherical symmetric aligned around their crystalline structured solvated ions. IPD_{plasma} are very stable domains, slightly more stable than CD_{plasma} . IPD_{plasma} form at concentrations below $C_{trans}^{IPD_{plasma}}$. On diluting below $C_{trans}^{IPD_{plasma}}$, CD_{plasma} transform into IPD_{plasma} , *i.e.*, the coherent plasma oscillations of the domains' solvated ions become in phase. The diameter of IPD_{plasma} equals that of CD_{plasma} at $C_{trans}^{IPD_{plasma}}$, *i.e.*, about 10^{-6} m. In contrast to the case for CD_{plasma} , the diameter of IPD_{plasma} does not significantly change with concentration. On diluting solutions below $C_{trans}^{IPD_{plasma}}$, the number of IPD_{plasma} diminishes.

- $CD_{elec}^{H_2O}$ -- these domains are composed of H_2O only. $CD_{elec}^{H_2O}$ cannot contain solutes. Solvated solutes, CD_{plasma} or IPD_{plasma} locate adjacent to $CD_{elec}^{H_2O}$. The H_2O constituting $CD_{elec}^{H_2O}$ coherently oscillate between their electronic ground state $|0\rangle$ and an excited $|b\rangle$ state. $CD_{elec}^{H_2O}$ formation is mediated by UV EMF. One electron of an H_2O residing in its $|b\rangle$ state is almost free (binding energy of about 0.4 eV). Hence, a $CD_{elec}^{H_2O}$ is a pool of $\sim 10^6$ quasi free electrons and quasi free protons. At ambient conditions, in bulk water: the fraction of H_2O included in $CD_{elec}^{H_2O}$ is about 20 percent; H_2O continually adsorb on $CD_{elec}^{H_2O}$ while simultaneously H_2O desorb, causing a $\sim 10^{-14}$ s timescale flickering landscape. Thus $CD_{elec}^{H_2O}$ observa-

^d The Debye length equals the distance beyond which the Coulomb electric field around a solute molecule is at any instant fully screened by all its neighboring solvent molecules.

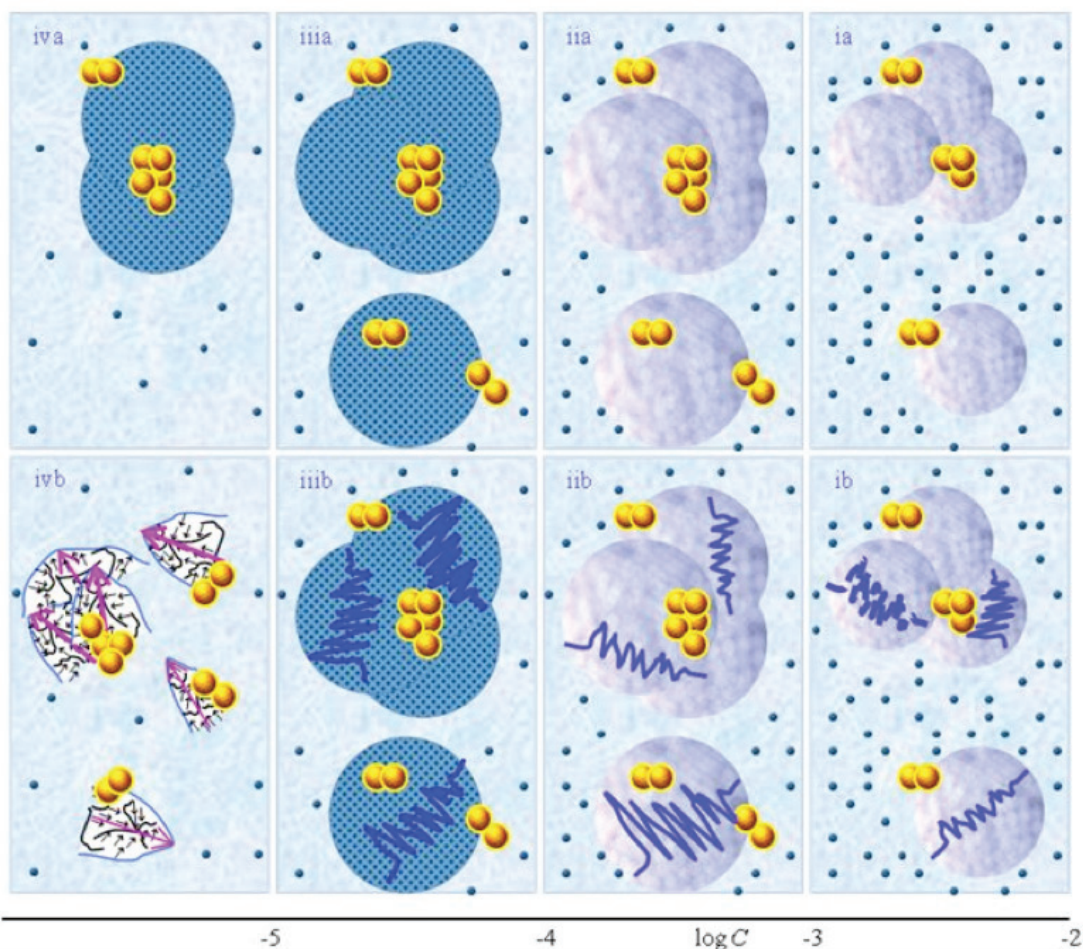


Figure 1a

Figure 1: This figure presents a schematic picture of serial diluted strong electrolyte solutions. The series in Figures 1(a) and (b) pertain to solutions which, respectively, were not vigorously shaken and those which were vigorously shaken after each dilutions step. Tiny blue balls represent randomly moving $\sim 10^{-9}$ m solvated ions. Yellow-brown balls and their agglomerates represent, respectively, $\sim 10^{-7}$ m $\text{CD}_{\text{elec}}^{\text{H}_2\text{O}}$ and supra- $\text{CD}_{\text{elec}}^{\text{H}_2\text{O}}$. Figures ia and iia illustrate that on dilution the diameter of $\text{CD}_{\text{plasma}}$ (symbolized with purple-blue colored balls) increases and the fraction of randomly moving solvated solutes diminishes. Figures iia and iiaa illustrate the transformation of $\text{CD}_{\text{plasma}}$ into $\text{IPD}_{\text{plasma}}$ at $C = C_{\text{trans}}^{\text{CD}_{\text{plasma}}} \approx 10^{-4}$ M. Note that the diameter of $\text{IPD}_{\text{plasma}}$ is that of $\text{CD}_{\text{plasma}}$ at $C = C_{\text{trans}}^{\text{CD}_{\text{plasma}}}$. Figures iiaa-va illustrate that on dilution the diameter of $\text{IPD}_{\text{plasma}}$ does not change, but the number of $\text{IPD}_{\text{plasma}}$ diminishes. Figures via-viia illustrate that below a certain concentration there are insufficient solutes to form $\text{IPD}_{\text{plasma}}$. The concentrations below which no $\text{IPD}_{\text{plasma}}$ form has yet not been theoretically derived. Figures via-viia illustrate that whenever there are too few ions to form $\text{IPD}_{\text{plasma}}$, the solution has the characteristics predicted by the customary models, i.e., all solvated electrolytes move randomly and their number diminishes on dilution. In the Figure 1b series, the blue zigzag curves symbolize shaken excites or cracks domains. Figures ib and iib illustrate that excitations or cracking does not significantly alter the internal structure of $\text{CD}_{\text{plasma}}$, which just as in Figure 1a series are represented with purple-blue colored balls. Figures iib and iibb illustrate the transition from $\text{CD}_{\text{plasma}}$ to $\text{IPD}_{\text{plasma}}$, with the latter pictured as blue-crystalline balls just as in the (a) series. Figures iibb and iibb illustrate that shaking excites or breaks up $\text{IPD}_{\text{plasma}}$. The excited or broken $\text{IPD}_{\text{plasma}}$ pieces, which in the text we denoted electric dipole aggregate ($\text{EDA}^{\text{IPD}_{\text{plasma}}}$), are pictured as irregular shaped aggregates in (ivb). The aligned black arrows orderings in $\text{EDA}^{\text{IPD}_{\text{plasma}}}$ symbolize these domains' distorted ferroelectric H_2O orderings. The purple arrows in the $\text{EDA}^{\text{IPD}_{\text{plasma}}}$ symbolizes these domains' dipole moments. Figures ivb and vb illustrate that on diluting below a critical concentration CD_{rot} get stabilized by $\text{EDA}^{\text{IPD}_{\text{plasma}}}$, i.e., the irregular shaped $\text{EDA}^{\text{IPD}_{\text{plasma}}}$ are located within the elongated

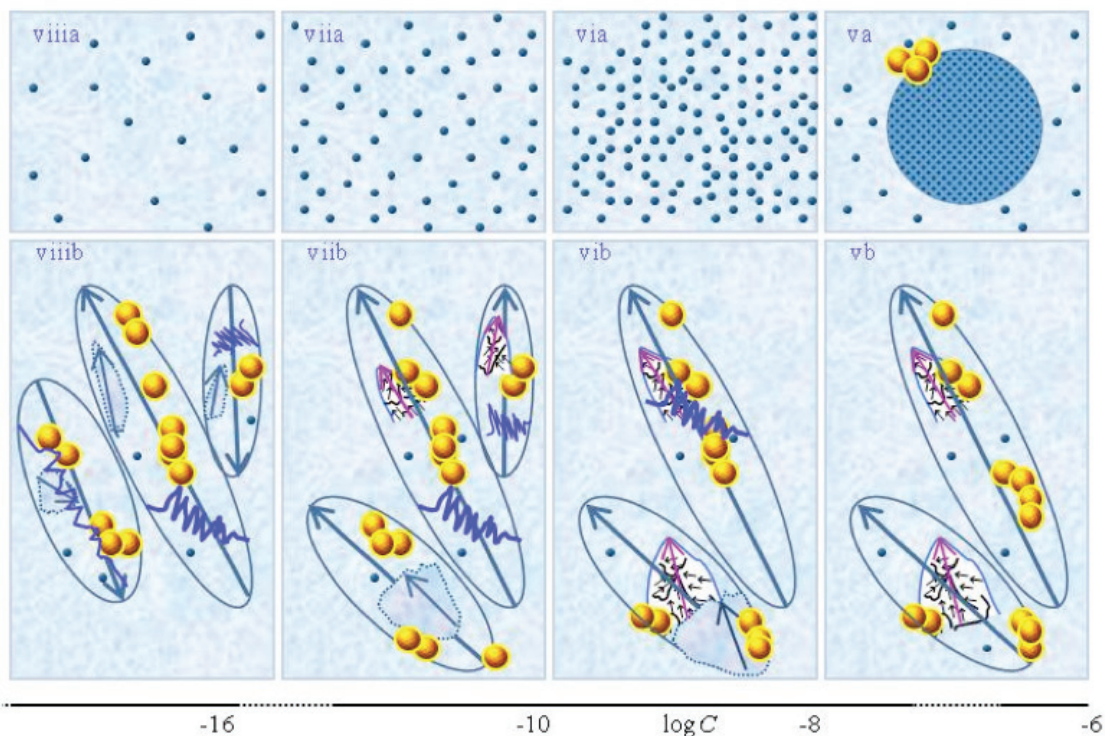


Figure 1b

ovals representing CD_{rot} . The mechanism underlying stabilization of CD_{rot} by $EDA^{IPDplasma}$ is explained in the text. The dark blue arrows symbolize the dipole moment of CD_{rot} . Figure vib shows that vigorous shaking excites or breaks up CD_{rot} . The excited or broken CD_{rot} pieces, which in the text we denoted electric dipole aggregate ($EDA^{CD_{rot}}$), are outlined with an irregular shaped broken line, e.g., the chunk located at the bottom of the CD_{rot} to the left in Figure vib. Figures vib-viiib show that at certain concentrations both $EDA^{IPDplasma}$ and $EDA^{CD_{rot}}$ are present within CD_{rot} , though the sizes of $EDA^{IPDplasma}$ diminish with concentration. Figure viiib shows that on diluting further, no $EDA^{IPDplasma}$ persist, i.e., there are too few solute particles to sustain $EDA^{IPDplasma}$. At these concentrations, vigorous shaking just breaks up CD_{rot} and creates new $EDA^{CD_{rot}}$. These in turn stabilize new CD_{rot} , as pictured in Figure viiib. Figures vb-viib illustrate that CD_{rot} may align with their dipole moments parallel. Figure viiib illustrates that at certain concentrations their dipoles may be aligned anti-parallel. Note that the sizes of the various domains, their broken pieces and the sizes of the solvated solutes with their hydration shells are not presented according to their realistic scale ratios.

tion requires fast resolution probes. CD_{rot} , CD_{plasma} and IPD_{plasma} may stabilize $CD_{elec}^{H_2O}$ i.e., reduce their flickering and ease their observation. $CD_{elec}^{H_2O}$ and supra- $CD_{elec}^{H_2O}$ may get encapsulated in CD_{rot} and supra- CD_{rot} . Such assemblies we denote $[supra-CD_{rot} < supra-CD_{elec}^{H_2O} >]$. The state of H_2O belonging to both CD_{rot} and $CD_{elec}^{H_2O}$ is a superposition of the state typifying the H_2O constituting CD_{rot} and the state typifying the H_2O constituting $CD_{elec}^{H_2O}$. The diameter of $CD_{elec}^{H_2O}$ is $\sim 10^{-7}$ m.

Superfluidic CD -- CD_{rot} , IPD_{plasma} and $CD_{elec}^{H_2O}$ are superfluidic domains, i.e., their

molecules do not collide (see Yinnon and Liu, 2015a). CD_{plasma} are not superfluidic. The superfluidity of CD has implications for the liquid's properties, e.g., its electric conductivity.

Schematic pictures of aqueous strong electrolyte solution -- Figures 1 ia-iiia communicate that for concentration above $C_{trans}^{IPDplasma}$, part of the solvated ions move randomly and part are organized in CD_{plasma} . Moreover these show $CD_{elec}^{H_2O}$ and supra- $CD_{elec}^{H_2O}$ are stabilized by CD_{plasma} . Comparing Figure 1ia and Figure 1iia highlights that the diameter of CD_{plasma} increases on

dilution. While on dilution a larger fraction of the solutes incorporate in CD_{plasma} , the increase in these domains' diameter mainly is due to incorporation of larger numbers of H_2O . Figure 1iia and Figure 1iiia exhibit the transition of CD_{plasma} into IPD_{plasma} . On comparing Figure 1iiia, Figure 1iva and Figure 1va, one discerns that the diameter of IPD_{plasma} does not significantly change with concentration. Instead on diluting, the number of IPD_{plasma} diminishes. Figures 1via-viiia illustrate that in very diluted solutions IPD_{plasma} do not form and all solvated solutes locate randomly.

SDVSASES's QED model

Figures 1 ib-viiib present a schematic picture of our SDVSASES model, *i.e.*, the structure of SDVSASES for different concentration ranges. Its details we discuss in the following paragraphs. The differences between Figure 1's (a) versus (b) series, is that the latter refer to solutions which were vigorously shaken after each dilution step, while the former were not vigorously shaken.

i. For $C > C_{\text{trans}}^{IPD_{\text{plasma}}}$, CD_{plasma} coexist with randomly located solvated electrolyte ions -- see Figure 1b and 1iib. The fraction of solutes and H_2O incorporated within CD_{plasma} , the diameter of CD_{plasma} , and agglomeration of CD_{plasma} into supra- CD_{plasma} increase on dilution (compare Figure 1 ib with 1iib). $CD_{\text{elec}}^{H_2O}$ stabilize and may form supra- $CD_{\text{elec}}^{H_2O}$ when their plasma oscillations resonate with those of CD_{plasma} . Resonance depends on concentration because the frequency of the plasma oscillations is proportional to $C^{3/4}$ (see Yinnon and Liu, 2015a). The aforesaid holds for all strong electrolyte solutions, independent of their preparation procedure, *i.e.*, not just for SDVSASES but also for solutions prepared without vigorous shaking or serial dilutions. Serial dilutions or vigorous shaking affect CD_{plasma} , mainly causing their breakup. However, CD_{plasma} reform after perturbations are over, as illustrated in

Figures 1 ib and 1iib.

ii. At $C = C_{\text{trans}}^{IPD_{\text{plasma}}}$, CD_{plasma} transform into IPD_{plasma} (see Figs. 1iia-b and 1iiia-b). The transition modifies electric conductivity and their dependence on concentration and time, because IPD_{plasma} are superfluidic and crystalline structured. Dilution below $C_{\text{trans}}^{IPD_{\text{plasma}}}$ diminishes the number of randomly moving solvated ions as well as the number of ions incorporated in IPD_{plasma} . $CD_{\text{elec}}^{H_2O}$ stabilize and may form supra- $CD_{\text{elec}}^{H_2O}$ when their plasma oscillations resonate with those of IPD_{plasma} . Aforesaid holds for all strong electrolytes solutions, independent of their preparation procedure.

iii. Vigorous shaking excites or breaks up IPD_{plasma} , as pointed out by Yinnon and Yinnon (2011) (see Figure 1iiib). Excitations induce years-long lasting vortices in the superfluidic IPD_{plasma} (Yinnon and Elia, 2013). [For a short discussion on these vortexes see Yinnon and Liu (2015a).] The vortexes partly destroy the spherical symmetric alignments of the dipole moments of their H_2O surrounding their crystalline ordered solvated ions. Hence excited IPD_{plasma} and their broken pieces have electric dipoles, *i.e.*, are electric dipole aggregates, which we denote $EDA^{IPD_{\text{plasma}}}$ (see Figure 1ivb). $EDA^{IPD_{\text{plasma}}}$ have the remnant crystalline structure of their "mother" IPD_{plasma} (Yinnon and Yinnon, 2011; Yinnon and Elia, 2013). (As for CD_{plasma} , only their solvation shells' few H_2O are aligned, *i.e.*, their perturbation, for example vigorous shaking, does not create 10^{-6} m-sized electric dipole aggregates.)

iv. $EDA^{IPD_{\text{plasma}}}$ induce electric dipoles in the quasi-free electron clouds of $CD_{\text{elec}}^{H_2O}$. The interactions between the dipole moments of these clouds, as well as between these and the dipole moments of $EDA^{IPD_{\text{plasma}}}$ may stabilize $CD_{\text{elec}}^{H_2O}$ and supra- $CD_{\text{elec}}^{H_2O}$ (see Figure 1 ivb).

v. For concentrations less than the critical

concentration for CD_{rot} formation (i.e., $C < C_{crit}^{CD_{rot}}$), due to the interactions between the dipoles of $EDA^{IPD_{plasma}}$ and H_2O , $EDA^{IPD_{plasma}}$ stabilize CD_{rot} and supra- CD_{rot} (Yinnon and Yinnon, 2011; Yinnon and Elia, 2013) -- see Figure 1vb. In other words, $EDA^{IPD_{plasma}}$, due to their significant asymmetric charge distributions, stabilize CD_{rot} .

Vigorous shaking excites or breaks up CD_{rot} (see Figure 1vib). Excitations induce years-long vortices in the superfluidic CD_{rot} . Due to ferroelectric ordering of the molecules constituting CD_{rot} , excited or broken CD_{rot} also are electric dipole aggregates, i.e., $EDA^{CD_{rot}}$ (see Figure 1vib). Unlike $EDA^{IPD_{plasma}}$, $EDA^{CD_{rot}}$ are not crystalline ordered. Due to interactions between the dipoles of $EDA^{CD_{rot}}$ and H_2O , $EDA^{CD_{rot}}$ also stabilize CD_{rot} . Therefore, serial dilutions with vigorous shaking at each dilution step diminish $EDA^{IPD_{plasma}}$ but $EDA^{CD_{rot}}$ persist. These $EDA^{CD_{rot}}$ stabilize CD_{rot} and supra- CD_{rot} too. As a result CD_{rot} persist up to ultra low concentrations and beyond (Yinnon and Yinnon, 2011; Yinnon and Elia, 2013) (see Figures 1vib-viiib).

vi. CD_{rot} induce electric dipoles in the quasi free electron clouds of $CD_{elec}^{H_2O}$. The interactions between the dipole moments of these clouds, as well as between these and the dipole moments of CD_{rot} or $EDA^{CD_{rot}}$ may stabilize $CD_{elec}^{H_2O}$ and supra- $CD_{elec}^{H_2O}$ (see Figure 1vb) (Del Giudice *et al.*, 2010).

vii. QED domains affect physicochemical properties, requiring adjustment in customary equations, e.g., that of electric conductivity (Yinnon and Yinnon, 2012). H_2O incorporated in $CD_{elec}^{H_2O}$, in CD_{rot} , in IPD_{plasma} or in the hydration shells of ions in CD_{plasma} do not collide. Also ions incorporated in CD_{plasma} or IPD_{plasma} do not collide. Hence in aqueous solutions of strong electrolytes, the electric conductivity is an inverse function only of intermolecular collisions involving: the randomly moving H_2O not included in the domains; randomly moving solvated

ions which are not incorporated in CD_{plasma} ; H_2O incorporated in CD_{plasma} but not part of the solvation shells of the ions included in these domains. A decrease of the fractions of these colliding particles enhances the electric conductivity. Also the electric dipole moments of $EDA^{IPD_{plasma}}$, of CD_{rot} , of $EDA^{CD_{rot}}$ and of the quasi free electron clouds of $CD_{elec}^{H_2O}$ reduce intermolecular collisions of randomly moving H_2O neighboring on these domains. The reduction raises electric conductivity (Yinnon and Yinnon, 2011; Yinnon and Elia, 2013). Currently, we are investigating quantitative implications.

Rendering our qualitative SDVSASES model, detailed above, into a quantitative one requires numerous computations, which are beyond this paper's scope.

Discussion

Correspondence Between SDVSASES Properties Predicted by QED, and Those Observed

Experimental data recently published, which evidence our SDVSASES model's properties i–vii, we cite, analyze and discuss in paragraphs i–vii, respectively.

i. Domains in $0.5\text{ M} < C < 2\text{ M}$ aqueous strong electrolytes were observed with laser light scattering, static light scattering and dynamic light scattering (DLS) (Li and Ogawa, 2000; Georgalis *et al.*, 2000; Samal and Geckeler, 2001; Sedlak 2006). The domains' properties agree with those of CD_{plasma} (Yinnon and Yinnon, 2009, 2012). For example, the domain's dissipative self-organizing and hysteresis properties point to EMFs' mediating roles. Moreover, the observed value for $C_{trans}^{IPD_{plasma}}$ in aqueous NaCl is $2 \times 10^{-4}\text{ M}$. Ryzhkina *et al.* (2012) expanded DLS to concentrations below 1.83 M for aqueous NaCl SDVSASES and found:

- (a) For $0.18\text{ M} < C < 1.83\text{ M}$, $\sim 3 \times 10^{-6}\text{ m}$ sized domains and $\sim 10^{-9}\text{ m}$ sized hydrated solvated ion complexes are present.

(b) At physiological $C=0.16$ M, the domain size distribution differs from that one at $C>0.16$ M. Domains with diameters in the range of 1×10^{-7} - 5×10^{-7} m also form, with $\sim 3 \times 10^{-7}$ m sized domains dominating.

(c) For $C=0.16$ M, keeping samples in Permalloy containers does not significantly affect the $\sim 3 \times 10^{-6}$ m sized domains, but destroys those with diameters spanning 1×10^{-7} - 5×10^{-7} m. *This is the earliest reported direct evidence, EMF mediate domains' formation in aqueous solutions of strong electrolytes.*

(d) For $C<0.15$ M, DLS cannot clearly distinguish the domains' sizes.

Finding (a) confirms the presence of hydrated randomly moving ions and $\sim 10^{-6}$ m sized CD_{plasma} . Finding (b) corroborates, at certain concentrations, CD_{plasma} stabilize 10^{-7} m $CD_{\text{elec}}^{\text{H}_2\text{O}}$ forming $\sim 3 \times 10^{-7}$ m supra- $CD_{\text{elec}}^{\text{H}_2\text{O}}$. Additional corroboration is provided by 190-300 nm UV absorbance spectra. For $\sim 10^{-4}$ M $< C < \sim 10^{-3}$ M SDVSASES,^e UV absorbance dependency on frequency is similar to that of Exclusion Zone Water and Iterative Nafionized Water -- see Figure 1 in Lo (1996a), Figure 2 in Chai *et al.* (2008), Figure 1a in Elia *et al.* (2013), ascribed to UV EMF interacting with the quasi free electrons of $CD_{\text{elec}}^{\text{H}_2\text{O}}$ (Yinnon *et al.*, 2015c).

^e The concentration of the stock solution, from which the SDVSASES are prepared, is an accurate measure. The prevalence of solutes within SDVSASES, reported by the experimentalists as C , is not a measured concentrations but a computed one. These C values are computed by multiplying the number of dilution steps with the degree of dilution at each step, *e.g.*, decimal or centesimal. Thus for example, a SDVSASES prepared by twice decimal diluting a 1 M stock solution will have a C of about 10^{-2} M. To emphasize the "computed" nature of SDVSASES' C reported by experimentalists, in this paper when citing these C values, we add a "~" sign, *e.g.*, $\sim 10^{-2}$ M.

SDVSASES' UV absorbance intensity depends on solute type and decreases with dilution (Lo, 1996a). As such it corresponds with the solute type and concentration dependency of the frequency of the plasma oscillations of the ions within CD_{plasma} . It also corresponds with the diminishment in the fraction of ions incorporated in CD_{plasma} , causing a reduction in the fraction of H_2O incorporated in $CD_{\text{elec}}^{\text{H}_2\text{O}}$. As to finding (c), with Permalloy mainly screening high frequency EMF, it indeed should destroy $CD_{\text{elec}}^{\text{H}_2\text{O}}$ mediated by UV EMF but little affect CD_{plasma} mediated by TetraHz - MegaHz EMF. Radio frequency screening is called for to expose TetraHz - MegaHz EMFs' roles. Finding (d) hints supra-domains blur the various domain types' diameters.

ii. At $C \approx C_{\text{trans}}^{\text{IPDplasma}}$, the observed aqueous strong electrolytes' measured molar conductivity dependence on concentration, *i.e.*, $\Lambda(C)$, sharp enhancement suggests superfluidity. For $\sim 5 \times 10^{-5}$ M $< C < C_{\text{trans}}^{\text{IPDplasma}}$ their measured molar conductivity dependence on macroscopic time, *i.e.*, $\Lambda(t)$, exhibits features typical of crystalline orderings and superfluidity (Lo and Li, 1999). These properties conform to those of solutions containing IPD_{plasma} (Yinnon and Yinnon, 2012). Solute dependent UV absorbance intensity's diminution with dilution for aqueous strong electrolytes with $\sim 10^{-5}$ M $< C < \sim 10^{-4}$ M (Lo, 1996a), just as mentioned in the previous paragraph, suggests UV EMF interacting with the quasi free electrons of $CD_{\text{elec}}^{\text{H}_2\text{O}}$. Only that in this paragraph mentioned concentration range, $CD_{\text{elec}}^{\text{H}_2\text{O}}$ stabilization is facilitated by IPD_{plasma} and UV absorbance's dilution dependence is commensurate with diminishment of ions incorporated in IPD_{plasma} , causing a reduction in the fraction of H_2O incorporated in $CD_{\text{elec}}^{\text{H}_2\text{O}}$.

iii. For $C < \sim 10^{-4}$ M $\approx C_{\text{trans}}^{\text{IPDplasma}}$, fingerprints of ferroelectric orderings participating in dissipative dynamics in SDVSASES were first identified in their electric conductivity, di-

electric permittivity, heat of mixing and pH data (Lo, 1996a; Lo *et al.*, 1996b; Elia and Niccoli, 2000). The fingerprints instigated studies of such orderings. Electrostatic models show thermal aggression prevents H₂O ferroelectric ordering in SDVSASES at ambient conditions (Wong and Lo, 1998). QED analyses of the electric conductivity, heat of mixing and pH data indicate: vigorously agitating SDVSASES excites or ruptures IPD_{plasma}, *i.e.*, creates EDA^{IPD}_{plasma}; after agitations are over dissipative processes occur with EDA^{IPD}_{plasma} forming supra-EDA^{IPD}_{plasma}; additional agitations split EDA^{IPD}_{plasma} and supra-EDA^{IPD}_{plasma} (Yinnon and Yinnon, 2011; Yinnon and Elia, 2013). IR spectra pass band coefficient fluctuations (IR-SPBCF) of SDVSASES are consistent with these dissipative processes. For SDVSASES of HCl, NaCl, KCl, MgCl₂ or CaCl₂, IR-SPBCF are larger than those of control water; for SDVSASES of KCl, IR-SPBCF are larger than for SDVSASES of KBr, KI or K₂SO₄; also for SDVSASES of CaCl₂, IR-SPBCF are larger than those for SDVSASES of CaBr₂, CaI₂ or CaSO₄ -- hinting the role of anions is larger than that of cations (Zubareva *et al.*, 2003a, 2003b). IR-SPBCF are attributable to domain agglomeration (Fontana, 1994). Analyzing the relative impact of the various alkaline or earth alkaline cations and halide anions on domain formation, structure and dynamics in SDVSASES is beyond this paper's scope.

Light-, atomic force- and electron force-microscopy images of evaporated drops of NaCl SDVSASES with concentration of 1.7×10^{-7} M (Lo *et al.*, 2009), also seem to confirm ferroelectric ordered H₂O. The images resemble ice-frost patterns on windows exhibiting $\sim 10^{-6}$ - 10^{-5} m elongated structures. Within each structure a feather-like pattern is observable, *i.e.*, a line directed along the structure's main axis intersecting at 102° with numerous parallel oriented stripes. With the angle between hydrogen and oxygen atoms in H₂O for ice I_h and va-

por, respectively, estimated at 109.47° and 104.5°, the observed 102° angle might be commensurate with H₂O bending affected by their ferroelectric ordering. [Ferroelectric mobile water recently has been investigated with molecular dynamics simulations (Nakamura and Ohno, 2011) -- their expansion for simulating EDA^{IPD}_{plasma} is called for.] Additional support for ferroelectric ordered H₂O comes from the 1500 - 500 cm⁻¹ IR spectrum of 10^{-7} M NaCl SDVSASES (Lo *et al.*, 2009),^f which differs from bulk water but is similar to that of Iterative Nafionized Water (Elia *et al.*, 2013). The spectra evoke H₂O librations in these liquids vary, with the variations attributable to ferroelectric ordered H₂O (Yinnon *et al.* 2015c). IR spectra of ferroelectric-ordered H₂O are scarce and mainly pertain to ice. Transitions from ice I_h to the ferroelectric-ordered ice XI are mainly reflected in librations (Arakawa *et al.*, 2009).

iv. For $\sim 10^{-13}$ M < C < $\sim 10^{-5}$ M, 190 - 300 nm UV absorbance intensity of SDVSASES as a function of concentration fluctuates, differs from that of bulk water, but only for $\sim 10^{-7}$ M < C < $\sim 10^{-5}$ M fluctuations depend on solute type -- see Figure 1a in Lo (1996a). These features are attributable to the quasi free electrons of CD^{H₂O}_{elec} interacting with UV EMF -- in particular because the UV absorbance's frequency dependency is similar to that of Exclusion Zone Water and Iterative Nafionized Water (Chai, 2008; Elia *et al.*, 2013), ascribed to the quasi free electrons of CD^{H₂O}_{elec} (Yinnon *et al.*, 2015c).

As to the solute dependent UV absorbance intensity, it evokes IPD_{plasma} and EDA^{IPD}_{plasma} stabilize CD^{H₂O}_{elec} and supra-CD^{H₂O}_{elec}. Electron Force Microscopy images support this evocation. These reveal that the $\sim 10^{-6}$ - 10^{-5} m elongated structures with their feather-like pattern, in paragraph iii conjectured to be EDA^{IPD}_{plasma}, have local charges on their surface generating -0.246 to 0.257 V elec-

tric potentials.^f These charges are attributable to the quasi free electrons of $CD_{elec}^{H_2O}$.

Also electric conductivity phenomena are commensurate with $EDA^{IPDplasma}$ stabilizing $CD_{elec}^{H_2O}$, as will be discussed in paragraphs vii.c.2-4. (The solute independent fluctuations for $\sim 10^{-13} \text{ M} < C < \sim 10^{-7} \text{ M}$, we discuss in paragraph vi.)

v. Transmission electron and optical microscopy images indicate stabilization of CD_{rot} . Transmission electron microscopy exposed $\sim 10^{-5} \text{ m}$ long and $10^{-7} - 10^{-6} \text{ m}$ wide strips in $\sim 10^{-11} \text{ M}$ NaCl SDVSASES (see Lo 1996a, Figure 3a). Optical microscopy revealed rounded or oval molecular associates with $\sim 10^{-4} \text{ m}$ diameters in $\sim 10^{-7} \text{ M}$ NaCl SDVSASES (see Lo *et al.*, 2009 Figure 4). The associates affect the liquids' dielectric permittivity (Lo *et al.*, 1996b). The strips conform to supra- CD_{rot} with the CD_{rot} organized in chain associates and their dipoles more or less parallel oriented. The rounded or oval associates conform to supra- CD_{rot} with CD_{rot} dipoles inverse-parallel oriented.

Electric conductivity, heat of mixing and pH data also indicate CD_{rot} stabilization for concentrations below $\sim 10^{-7} \text{ M}$ (Elia and Niccoli, 1999, 2000, 2004a; Yinnon and Yinnon, 2011; Yinnon and Elia, 2013). The data reflect CD_{rot} , and EDA^{CDrot} 's distinctive macroscopic time scale (months) dissipative dynamics underlying their agglomeration and reorganization in supra-domains. The data also expound that diluting without vigorous shaking the liquid reduces CD_{rot} and EDA^{CDrot} numbers, with the reduction similar to the dilution ratio.

^f Methodological aspects of Lo *et al.* (2009), e.g., Light-, atomic force- and electron force-microscopy and IR measurements, were recently criticized (Kožíšek *et al.*, 2013) and defended (Lo, 2013). With these techniques' potential to reveal $EDA^{IPDplasma}$, EDA^{CDrot} and IPD_{plasma} , confirmation of Lo *et al.* (2009) findings by independent research groups is called for.

The dissipative dynamics of CD_{rot} and EDA^{CDrot} ostensibly also are reflected in IR-SPBCF. At a solute dependent concentration, much smaller than $C_{trans}^{IPDplasma}$, e.g., $C \sim 10^{-7} \text{ M}$ for KCl SDVSASES and $C \sim 10^{-8} \text{ M}$ for $CaCl_2$ SDVSASES, IR-SPBCF grow; at $C \sim 10^{-10} \text{ M}$ for KCl SDVSASES as well as for $CaCl_2$ SDVSASES, IR-SPBCF have a maximum; a second maximum appears at $C \sim 10^{-13} \text{ M}$ for KCl SDVSASES and at $C \sim 10^{-14} \text{ M}$ for $CaCl_2$ SDVSASES (Zubareva *et al.*, 2003a). Hitherto, to the best of our knowledge, these IR-SPBCF enhancements are not explained in the context of QED. We ascribe these to $EDA^{IPDplasma}$ stabilizing the $\sim 10^{-5} - 10^{-4} \text{ m}$ CD_{rot} and their organization in supra- CD_{rot} , i.e., $C_{crit}^{CDrot} \sim 10^{-7} \text{ M}$ for KCl SDVSASES and $C_{crit}^{CDrot} \sim 10^{-8} \text{ M}$ for $CaCl_2$ SDVSASES. As to the maxima at $C \sim 10^{-10} \text{ M}$, $C \sim 10^{-13} \text{ M}$ and $C \sim 10^{-14} \text{ M}$, also for IR-SPBCF of serial diluted vigorous shaken solutions of non-electrolytic compounds, maxima at similar concentrations were observed. As discussed by Yinnon and Liu (2015b), other variables of these non-electrolyte solutions (e.g., dielectric permittivity, electrokinetic potential, electric conductivity and domains' diameter) too have extremums at these concentrations and seemingly are related to CD_{rot} agglomeration, i.e., the orientations of the dipole moments of CD_{rot} and EDA^{CDrot} within supra- CD_{rot} .

vi. Groupings of $\sim 10^{-7} \text{ m}$ domains, located within the 10^{-4} m long strips described in the previous paragraph, were depicted by transmission electron microscopy (see Figure 3 in Lo, 1996a). Their density within the strip increases on adding dielectric materials to SDVSASES. We identify the $\sim 10^{-7} \text{ m}$ domains as $CD_{elec}^{H_2O}$, their groupings as supra- $CD_{elec}^{H_2O}$ and the strip containing these as supra- $CD_{rot} < \text{supra-}CD_{elec}^{H_2O} >$, because:

- (a) 190-300 nm UV spectral features of SDVSASES for $\sim 10^{-13} \text{ M} < C < 10^{-7} \text{ M}$ (Lo, 1996a) are solute independent, differ from bulk water and are similar to those of Ex-

clusion Zone Water and Iterative Nafionized Water (Chai, 2008; Elia *et al.*, 2013). For Exclusion Zone Water and Iterative Nafionized Water, these features were ascribed to the quasi free electrons of $CD_{elec}^{H_2O}$ interacting with UV EMF (Yinnon *et al.*, 2015c).

(b) 2800 to 3800 cm^{-1} IR main H_2O stretching band of $\sim 10^{-7}$ M NaCl SDVSASES differ from bulk water, *i.e.*, the former is red shifted by ~ 100 cm^{-1} (Lo *et al.*, 2009).^f Iterative Nafionized Water exhibits similar features (Elia *et al.*, 2013), which are attributable to intramolecular interactions of H_2O within $CD_{elec}^{H_2O}$ (De Ninno and Congiu Castellano, 2011; De Ninno *et al.*, 2013; Yinnon *et al.*, 2015c).

(c) Electric conductivity phenomena agree with EDA^{CDrot} stabilizing $CD_{elec}^{H_2O}$ -- see below vii.c.5-6 and vii.d.

(d) The electric dipole moments of CD_{rot} and those of the clouds of the quasi free electrons interacting with the dielectric material contributes to supra- CD_{rot} <supra- $CD_{elec}^{H_2O}$ > stabilization (Yinnon *et al.*, 2015c).

(e) A domain diameter of $\sim 10^{-7}$ m is similar to the diameter of $CD_{elec}^{H_2O}$.

Ho (2014) conjectured the $\sim 10^{-7}$ m domains in $\sim 10^{-11}$ M and in $\sim 10^{-7}$ M NaCl SDVSASES observed by Lo *et al.* (1996a, 2009) are electrets comprised of $CD_{elec}^{H_2O}$. She reasoned that the spherical $CD_{elec}^{H_2O}$ can mimic dipole interactions through the quasi free electrons on their periphery attracting positive charges just outside their borders. Consequently, $CD_{elec}^{H_2O}$ s form a three-dimensional potentially perfectly symmetrical giant electret (dipole); there will be a dipole electric field in any direction; the electret's 6-fold symmetry arises from close-packing of the spherical $CD_{elec}^{H_2O}$ resulting in 'snowflake' like clusters. The combination of the coherent electronic oscillations of the H_2O within $CD_{elec}^{H_2O}$ (mediated by the EMFs con-

densed within their $CD_{elec}^{H_2O}$), together with coherent rotational oscillations of these molecules, produces phase-locked coherent interactions among the $CD_{elec}^{H_2O}$ s (as identified by Del Giudice *et al.*, 2010), resulting in stable supramolecular clusters with the electret structure.

Moreover, Ho inferred that the initiating solute of the SDVSASES has the role of aligning the $CD_{elec}^{H_2O}$, while the sequential dilutions and vigorous shaking stimulates the coherent phase locking of the rotational oscillations among $CD_{elec}^{H_2O}$ s; as the solution becomes diluted, the vigorous shaking breaks up the clusters into small pieces, seeding more clusters that align with one another or coalesce into larger ones. This meta-stable state will spontaneously break symmetry to favor one direction over all others when drops are placed in contact with a solid substrate, thereby giving rise to a wide variety of aggregates or clusters.

Phase-locking between $CD_{elec}^{H_2O}$ facilitated by coherent rotational oscillations of their molecules [cited in the last paragraph] underlies the [supra- CD_{rot} <supra- $CD_{elec}^{H_2O}$ >] formation mechanism (detailed in our SDVSASES model's paragraph vi). However, to the best of our knowledge, the interactions between the initiating solutes and $CD_{elec}^{H_2O}$ resulting in alignment of the latter, as well as the need for sequential dilution with succussions for stimulating the phase-locking, were not elucidated in Ho's (2014) or other publications. We regard IPD_{plasma} 's formation below $C_{trans}^{IPDplasma}$, their vigorous shaking induced excitation or break up leading to $EDA^{IPDplasma}$ creation, CD_{rot} 's stabilization by $EDA^{IPDplasma}$ for concentrations below C_{crit}^{CDrot} , and EDA^{CDrot} creation by vigorous shaking to be the central aspects of our model required for explaining SDVSASES's properties, as detailed by Yinnon and Yinnon (2011) and Yinnon and Elia (2013).^g

^g As to the energetics of processes induced by vigorous shaking of SDVSASES, to the best of

As to stabilization of $CD_{elec}^{H_2O}$ and their agglomeration in supra- $CD_{elec}^{H_2O}$, triggered by their interactions with CD_{rot} , $EDA^{IPD_{plasma}}$, $EDA^{CD_{rot}}$, CD_{plasma} or IPD_{plasma} , according to our model it affects some SDVSASES physicochemical properties.

Paragraphs' iii and v cited data, indicating ferroelectric ordering of H_2O , do not unambiguously differentiate between $EDA^{IPD_{plasma}}$, CD_{rot} and $EDA^{CD_{rot}}$. Only IR-SPBCF point to a $C_{crit}^{CD_{rot}}$. Also differences in the diameters of the various domains signify dissimilar ordering types. Disparities between

our knowledge, these have not been quantified. In depth study of these is important, but outside the scope of this paper. While awaiting the results of such a study, we note that on stirring with a magnetic stirrer one liter of water contained in a glass vessel, the power consumption amounts to a few Joule/sec. Most of the applied energy heats the system and dissipates to the surroundings (more than 95 percent); only a small part of it will excite or break up molecular aggregates (Raine and So, 1993). Consequently, on shaking SDVSASES for example for one minute, the energy available for excitation or break-up of aggregates is of the order of a few Joule, *i.e.*, 10^{18} - 10^{19} eV. Gravimetric data indicate that about 1 to 10 percent of the molecules in 45 times serial decimal diluted vigorous shaken solutions are organized in aggregates (Elia and Napoli, 2010), *i.e.*, the number of associated molecules in one liter of such liquids is of the order of about 10^{22} - 10^{23} . A 10^{-5} - 10^{-4} m sized CD_{rot} contains about 10^{15} - 10^{18} H_2O . Accordingly, one liter of SDVSASES might contain about 10^4 - 10^8 CD_{rot} . Thus 10^{18} - 10^{19} eV implies 10^{10} - 10^{15} eV per aggregate. The energy for desorption of one H_2O from a CD_{rot} is of the order of 10^{-2} eV. The aforementioned numerical analysis alludes that vigorous shaking indeed may affect CD_{rot} and supra- CD_{rot} . As to the $\sim 10^{-6}$ m sized IPD_{plasma} , with a few eV required for desorption of one of its molecules, one reaches at a similar allusion.

ferroelectric orderings present at $\sim 10^{-18}$ $M < C < \sim 10^{-6}$ M ranges, however, were exposed for serial diluted vigorous shaken solutions of weak- or non-electrolytic compounds by measuring their dielectric permittivity, as we discuss in Yinnon and Liu (2015b). Thus analogous dielectric permittivity measurements for SDVSASES are called for. While awaiting their results, we note that electric conductivity data conform with the central aspects of our model (Yinnon and Yinnon, 2011; Yinnon and Elia, 2013), in particular the electric conductivity analyses we present below in vii.(c).

vii. Various electric conductivity measures for SDVSASES were reported:

(a) For $\sim 2.5 \times 10^{-2}$ M $< C < \sim 3.5 \times 10^{-1}$ M aqueous NaCl, KCl, NaOH or HCl, Lo and Li (1999) measured the molar conductivity as a function of $C^{1/2}$, *i.e.*, $\Lambda(C^{1/2})$. They did not specify their dilution procedure. They found that for the aforementioned narrow concentration range, $\Lambda(C^{1/2})$'s linear dependence on $C^{1/2}$ agrees with that predicted by the customary electrostatic models. In these models (Robinson and Stokes, 2002), it is assumed that at all concentrations: all ions are in a "gas-like" state, move independently, share in the liquid's Brownian motion; on applying an alternating voltage to electrodes placed in the liquid, the resulting alternating current electric fields experienced by the ions bias their movement; ion-ion, ion- H_2O and H_2O - H_2O collisions dampen the ions' movements induced by the alternating current electric field. The electrostatic models were mainly developed during 1930 - 1950. To attain quantitative agreement between predicted and measured $\Lambda(C^{1/2})$, empirical constants inclusion in $\Lambda(C^{1/2})$ equations proved necessary. The constants were supposed to reflect the electrophoretic and relaxation effects. Even their inclusion only enabled fitting theoretical to experimental data for nar-

row concentration ranges, *e.g.*, ranges of about 0.1 M for $C < \sim 0.1$ M, as is the case for Lo and Li's aforementioned findings. Consequently hitherto according to electrostatic theories, $\Lambda(C^{1/2})$ are puzzling phenomena (Robinson and Stokes, 2002). Domains with their concentration dependent prevalence, observed during the last 15 years, in tandem with QED promise a solution for these puzzles. In particular, because QED indicates: plasma oscillations of all ions within a CD_{plasma} or a supra- CD_{plasma} are coherent and resonate with EMF condensed within the domain, preventing these ions and their hydration H_2O to collide (a single collision would destroy the coherence); the fraction of ions incorporated in CD_{plasma} depends on concentration; CD_{plasma} stabilizing $CD_{\text{elec}}^{H_2O}$ and supra- $CD_{\text{elec}}^{H_2O}$ depends on concentration, hence the fraction of H_2O included in $CD_{\text{elec}}^{H_2O}$ depends on concentration; the H_2O included in $CD_{\text{elec}}^{H_2O}$ and supra- $CD_{\text{elec}}^{H_2O}$ also oscillate coherently and do not collide.

The aforesaid implies that the electrostatic models' assumptions only partly hold, and their empirical constants most likely also reflect domain presence. Currently, we attempt to develop a QED $\Lambda(C^{1/2})$ model. For $C > C_{\text{trans}}^{\text{IPDplasma}}$, it foremost requires deriving: the fraction of ions included in CD_{plasma} and its dependence on concentration; the fraction of H_2O included in $CD_{\text{elec}}^{H_2O}$ and its dependence on concentration; interactions between an electric field induced by alternating currents, the ions incorporated in CD_{plasma} , and the quasi free electrons of $CD_{\text{elec}}^{H_2O}$; average supra- CD_{plasma} and supra- $CD_{\text{elec}}^{H_2O}$ diameters. Its future verification warrants accurate data on domain prevalence and the diameter of the domains for a wide concentration range. Currently such data are not available. Appropriate measurements are called for. In particular under ambient and hypo-electromagnetic conditions, *i.e.*, in containers screening high frequency or radio frequency radia-

tion. These are capable of elucidating, respectively, the fraction of H_2O included in $CD_{\text{elec}}^{H_2O}$ and its dependence on concentration, the fraction of ions incorporated in CD_{plasma} and its dependence on concentration.

(b) For $\sim 5 \times 10^{-5} \text{ M} < C < \sim 5 \times 10^{-4} \text{ M}$ aqueous NaCl, KCl, NaOH or HCl, Lo and Li (1999) measured $\Lambda(C^{1/2})$ and the time dependence of molar conductivity $\Lambda(t)$. They did not specify their dilution procedure. They found:

1. $\Lambda(C^{1/2})$ has an inflection point at $C = 1.7 \times 10^{-4} \text{ M}$ [see Figures 1 and 2 in Lo and Li (1999)]. For $1.7 \times 10^{-4} \text{ M} < C < 5 \times 10^{-4} \text{ M}$, $\Lambda(C^{1/2})$ is a gentle negatively sloped curve. For $3.0 \times 10^{-5} \text{ M} < C < 1.7 \times 10^{-4} \text{ M}$, $\Lambda(C^{1/2})$ is linear with a huge negative slope, indicating a phase transition.

2. $\Lambda(t)$ oscillates for $3 \times 10^{-5} \text{ M} < C < 2 \times 10^{-4} \text{ M}$. Fourier transforms of $\Lambda(t)$ reveal spectra with sharp resonances. Two dominant peaks at 0.38 and 0.48 Hz, with strongly concentration dependent intensities (maximal at $C = 1.7 \times 10^{-4} \text{ M}$), are observable in Figures 3 and 5 in Lo and Li (1999). These features point to crystalline structured domains present in a narrow concentration range -- as discussed in Yinnon and Yinnon (2012).

3. Amplitudes of $\Lambda(t)$ oscillations (A) are C dependent, and maximal at $C = 1.7 \times 10^{-4} \text{ M}$. Decomposing Λ into two parts, $\Lambda = \bar{\Lambda} + A$ with $\bar{\Lambda}$ representing average Λ , reveals the ratio $\frac{A}{\bar{\Lambda}}$'s dependence on concentration, *i.e.*, $\frac{A}{\bar{\Lambda}}(C)$. It has a sharp peak at $C = 1.7 \times 10^{-4} \text{ M}$, a steeply negative sloped curve for $1.7 \times 10^{-4} \text{ M} < C < 2.0 \times 10^{-4} \text{ M}$, a gentle positively sloped curve for $3.0 \times 10^{-5} \text{ M} < C < 1.7 \times 10^{-4} \text{ M}$ [see Figure 4 in Lo and Li (1999)]. As such $\frac{A}{\bar{\Lambda}}(C)$ resembles the temperature-dependent transition from normal helium I liquid to superfluid helium II, pointing to superfluidic structures.

QED analyses show features (1) - (3) fully agree with CD_{plasma} to IPD_{plasma} transitions (Yinnon and Yinnon, 2012). These reflect: IPD_{plasma} superfluidic crystalline nature; the fraction of ions incorporated in IPD_{plasma} dependence on concentration, *i.e.*, the fraction diminishes on dilution due to reduction in IPD_{plasma} numbers -- see SDVSASES's model's paragraph ii. As such, measuring $\Lambda(C^{1/2})$, $\Lambda(t)$ and $\frac{\Lambda}{\Lambda}(C)$ enables unambiguous identification of IPD_{plasma} and the fraction of ions incorporated in IPD_{plasma} dependence on concentration, while analyses of Fourier transforms of $\Lambda(t)$ enable delineating their crystalline features. Effects of vigorous shaking on $\Lambda(t)$ Fourier spectra have not yet been analyzed. We expect $EDA^{IPD_{\text{plasma}}}$, created by vigorous shaking induced excitations or break up of IPD_{plasma} , to affect the spectra. Research is called for to investigate experimentally such effects and to develop Fourier transform analyses of $\Lambda(t)$ as a tool for analyzing $EDA^{IPD_{\text{plasma}}}$ creation, their characteristics and their agglomeration into supra- $EDA^{IPD_{\text{plasma}}}$.

(c) For $\sim 2 \times 10^{-15} \text{ M} < C < \sim 1 \times 10^{-4} \text{ M}$ NaCl SDVSASES, Ryzhkina *et al.* (2012) measured the electric conductivity for samples kept at laboratory bench (χ_{lb}) or in Permalloy containers (χ_{p}) and found:

1. For $\sim 3 \times 10^{-5} \text{ M} < C < \sim 1 \times 10^{-4} \text{ M}$, χ_{lb} steeply increases with concentration, *i.e.*, from $\sim 6 \mu\text{S/cm}$ at $C \approx 3 \times 10^{-5} \text{ M}$ to $25 \mu\text{S/cm}$ at $C \approx 1 \times 10^{-4} \text{ M}$. This finding corresponds with that cited above in paragraph vii.(b).1. It confirms our QED SDVSASES model's prediction ii.
2. For $\sim 3 \times 10^{-5} \text{ M} < C < \sim 1 \times 10^{-4} \text{ M}$, χ_{lb} and χ_{p} do not significantly differ. This finding agrees with our QED SDVSASES model's prediction that IPD_{plasma} , and $EDA^{IPD_{\text{plasma}}}$ formation is mediated by TetraHz - MegaHz EMF, which are not effectively screened by Permalloy. Hence keeping samples in Permalloy contain-

ers should not significantly affect these domains, but it might affect $CD_{\text{elec}}^{\text{H}_2\text{O}}$ stabilized by IPD_{plasma} or $EDA^{IPD_{\text{plasma}}}$ -- respectively, see ii and iv above. Screening samples from radio frequency radiation is called for to expound electrodynamic interactions underlying IPD_{plasma} and $EDA^{IPD_{\text{plasma}}}$ formation. Difference in the dependence of electric conductivity on concentration observed for SDVSASES samples screened by Permalloy or radio frequency-screening materials promises elucidating relative prevalence of IPD_{plasma} and EDA_{plasma} versus prevalence of $CD_{\text{elec}}^{\text{H}_2\text{O}}$.

3. For $\sim 2 \times 10^{-6} \text{ M} < C < \sim 3 \times 10^{-5} \text{ M}$, both χ_{lb} and χ_{p} are about constant, *i.e.*, respectively, $\chi_{\text{lb}} = 6 \mu\text{S/cm}$ and $\chi_{\text{p}} = 2.5 \mu\text{S/cm}$. (Doubly distilled water used for preparing and diluting SDVSASES had an electric conductivity below $1.5 \mu\text{S/cm}$.) The difference between χ_{lb} and χ_{p} indicates domains mediated by high frequency EMF are present. In correspondence with our SDVSASES model's prediction iv and its evidence presented in paragraph iv, the difference is attributable to $CD_{\text{elec}}^{\text{H}_2\text{O}}$ and supra- $CD_{\text{elec}}^{\text{H}_2\text{O}}$ stabilized by IPD_{plasma} and $EDA^{IPD_{\text{plasma}}}$.

4. For $\sim 2 \times 10^{-8} \text{ M} < C < \sim 2 \times 10^{-6} \text{ M}$, on diluting from $C \approx 2 \times 10^{-6} \text{ M}$ to $C \approx 2 \times 10^{-8} \text{ M}$ both χ_{lb} and χ_{p} more or less linearly approach $\sim 2.5 \mu\text{S/cm}$. Most likely, this indicates that dilution-induced reduction in IPD_{plasma} and $EDA^{IPD_{\text{plasma}}}$ numbers diminishes $CD_{\text{elec}}^{\text{H}_2\text{O}}$ prevalence.

5. For $\sim 1 \times 10^{-13} \text{ M} < C < \sim 2 \times 10^{-8} \text{ M}$, on diluting from $C \approx 2 \times 10^{-8} \text{ M}$, χ_{lb} linearly increases from $\sim 2.5 \mu\text{S/cm}$ till it reaches a maximum of $\sim 7 \mu\text{S/cm}$ at $C \approx 10^{-10} \text{ M}$. Additional dilutions to $C \approx 10^{-13} \text{ M}$ diminish χ_{lb} more or less linearly to $2 \mu\text{S/cm}$. IR-SPBCF of SDVSASES too exhibit a maximum at $C \approx 10^{-10} \text{ M}$ (see paragraph v). IR-SPBCF and features in SDVSASES UV and 2800 to 3800 cm^{-1} IR spectra for

$C < 10^{-7}$ M, we attributed to $\text{EDA}^{\text{IPDplasma}}$ stabilizing the $\sim 10^{-5} - 10^{-4}$ m CD_{rot} and their agglomeration into supra- CD_{rot} (see paragraph v), with these subsequently stabilizing $\text{CD}_{\text{elec}}^{\text{H}_2\text{O}}$ and supra- $\text{CD}_{\text{elec}}^{\text{H}_2\text{O}}$ resulting in supra- $\text{CD}_{\text{rot}} < \text{supra-CD}_{\text{elec}}^{\text{H}_2\text{O}} >$ formation (see paragraph vi). χ_p measurements provide additional verification for this attribution.

On diluting from $C \approx 2 \times 10^{-8}$ M to $C \approx 2 \times 10^{-15}$ M, χ_p smoothly diminishes from ~ 2.5 $\mu\text{S}/\text{cm}$ to 2 $\mu\text{S}/\text{cm}$. The significant differences between χ_{lb} and χ_p are ascribable to the absence of domains in the samples screened by Permalloy. Thus the threshold concentration (C_{thr}), below which no domains are present in samples screened by Permalloy, is $\sim 2 \times 10^{-8}$ M. This absence of domains indeed is consistent with IR and UV EMF, respectively, mediating CD_{rot} and $\text{CD}_{\text{elec}}^{\text{H}_2\text{O}}$ formation. Our attribution that χ_{lb} 's distinctive changes at $C \approx 2 \times 10^{-8}$ M result from CD_{rot} stabilization implies for aqueous NaCl that $C_{\text{crit}}^{\text{CDrot}} \approx C_{\text{thr}} \approx 2 \times 10^{-8}$ M. The differences between χ_{lb} and χ_p for $C < 2 \times 10^{-8}$ M -- a concentration range at which $\text{IPD}_{\text{plasma}}$ and $\text{EDA}^{\text{IPDplasma}}$ prevalence is very low -- connotes screening by Permalloy facilitates distinguishing between ferroelectric ordering of H_2O in CD_{rot} and its broken pieces ($\text{EDA}^{\text{CDrot}}$) versus that one in $\text{EDA}^{\text{IPDplasma}}$ or $\text{IPD}_{\text{plasma}}$. Our attribution $\text{EDA}^{\text{IPDplasma}}$ stabilizes CD_{rot} at $C \approx 2 \times 10^{-8}$ M also means that only when vigorous shaking transforms $\text{IPD}_{\text{plasma}}$ into $\text{EDA}^{\text{IPDplasma}}$ CD_{rot} can form, i.e., the observed absence of supramolecular orderings for $C < C_{\text{crit}}$ in serial diluted solutions which at each dilution step are not vigorously shaken (Elia and Niccoli, 1999, 2000, 2004a) means $C_{\text{crit}} = C_{\text{crit}}^{\text{CDrot}}$.

6. On diluting from $C \approx 2 \times 10^{-13}$ M to $C \approx 2 \times 10^{-15}$ M, χ_{lb} more or less linearly increases from 2 $\mu\text{S}/\text{cm}$ to 2.5 $\mu\text{S}/\text{cm}$ while χ_p stays constant at 2 $\mu\text{S}/\text{cm}$. These data

indicate presence of few CD_{rot} , $\text{CD}_{\text{elec}}^{\text{H}_2\text{O}}$ and supra- $\text{CD}_{\text{rot}} < \text{supra-CD}_{\text{elec}}^{\text{H}_2\text{O}} >$. As such these support our earlier conclusions based on IR-SPBCF (see paragraphs v-vi).

(d) For 10^{-24} M $< C < \sim 10^{-9}$ M as well as for solutions diluted beyond $\sim 10^{-24}$ M, for aqueous SDVSASES of NaCl or MgCl, Elia *et al.* (2008) and Belon *et al.* (2008) measured $\chi_{\text{lb}}^{\text{excess}} \neq 0$. Here $\chi_{\text{lb}}^{\text{excess}}$ represent the difference between χ_{lb} of SDVSASES and χ_{lb} of serial diluted solutions with chemical composition equivalent to that of SDVSASES but prepared without vigorous shaking at each dilution step. $\chi_{\text{lb}}^{\text{excess}}$ zig-zag-like varies with concentration. $\chi_{\text{lb}}^{\text{excess}}$ increases with the sample's age, with the increment being an inverse function of the sample's volume. QED analyses by Yinnon and Elia (2013) show: the aging effect is attributable to CD_{rot} agglomeration dynamics; the volume effect is attributable to interfaces contributing to CD_{rot} stabilization -- samples with smaller volume have larger surface/volume ratio, leading to enhanced CD_{rot} stabilization.

(e) The findings and related conclusions, presented in aforementioned paragraphs (c 1-6) and (d), imply modeling the electric conductivity dependence on concentration for $C < \sim 3 \times 10^{-5}$ M SDVSASES requires adequate description of the alternating current electric field interactions with the dipole moments of $\text{EDA}^{\text{IPDplasma}}$, of CD_{rot} , of $\text{EDA}^{\text{CDrot}}$ and of the quasi free electrons clouds of $\text{CD}_{\text{elec}}^{\text{H}_2\text{O}}$. Since domains with electric dipoles may align parallel or anti-parallel, seemingly spin models are required for generating adequate distributions of supra- $\text{EDA}^{\text{IPDplasma}}$, supra- $\text{EDA}^{\text{CDrot}}$ and supra- CD_{rot} .

The experimental data cited in the above paragraphs i-vii and their analyses support our SDVSASES model's aspects i-vii, respectively.

Conclusions

Domain formation in SDVSASES, mediated by EMF, is expounded in this paper. These liquids' QED model (proposed in 2011) in the past facilitated explicating their measured physicochemical properties. In this paper we show it also enables consistently explaining their recently observed properties for concentrations down to $\sim 10^{-20}$ M.

Our main findings are:

A. H_2O interacting with EMF underlying the 10^{-5} - 10^{-4} m sized domains in SDVSASES at concentrations below C_{crit}^{CDrot} , which is a basic tenet of the model, for the first time is unambiguously confirmed by this study's analyses of experiments by Konovalov's group [see Ryzhkina *et al.* (2012); Konovalov and Ryzhkina (2014)]. Conditions for H_2O ferroelectric auto-ordering in 10^{-5} - 10^{-4} m sized domains mediated by EMF were predicted by Del Giudice *et al.* (1988) and Del Giudice and Vitiello (2006) with QED. These domains, denoted CD_{rot} in previous publications, are quantum manifestations of a classical physics liquid-liquid phase transition in polar liquids (Sivasubramanian *et al.*, 2005). Experimental evidence for this phase transition was recently obtained for water perturbed by Nafion membranes (Yinnon *et al.*, 2015c). As to QED's predictions concerning CD_{rot} 's size, EMF mediated auto-organization, ferroelectric ordering of its H_2O and C_{crit}^{CDrot} , these are for the first time verified by this paper's analyses of $\sim 10^{-20}$ M $< C < \sim 10^{-1}$ M SDVSASES. The analyses also indicate $\sim 10^{-10}$ M $< C_{crit}^{CDrot} < \sim 10^{-6}$ M depends on solute type -- hitherto C_{crit}^{CDrot} values have not been *ab initio* derived.

B. H_2O interactions with EMF resulting in about 10^{-7} m sized domains [predicted by Preparata, (1995 chapter 10) and Arani *et al.* (1995) with QED] is for the first time verified by our analyses of

SDVSASES properties measured by Ryzhkina *et al.* (2012) and Konovalov and Ryzhkina (2014). Previous studies provided indirect evidence for these domains, which were denoted $CD_{elec}^{H_2O}$ (Yinnon and Yinnon, 2009; Del Giudice *et al.*, 2010, 2013, Montagnier *et al.*, 2011). Analyses of water perturbed by Nafion verified characteristics of the phase transition underlying their formation (Yinnon *et al.*, 2015c). Our analyses verify $CD_{elec}^{H_2O}$'s predicted size, $CD_{elec}^{H_2O}$ quasi free electrons, EMF mediated auto-organization of $CD_{elec}^{H_2O}$ and their stabilization by CD_{rot} for concentrations below C_{crit}^{CDrot} and by other domain types for concentrations above C_{crit}^{CDrot} .

C. Our analyses corroborate and complement conclusions drawn in our previous QED studies of SDVSASES. In particular, their domains not forming under hypo-electromagnetic conditions [as demonstrated by Ryzhkina *et al.* (2012) and Konovalov and Ryzhkina (2014)] signify electrodynamic interactions may play significant roles in water and its solutions. Thus, our study underlines: the customary assumptions that only electrostatic interactions between molecules in aqueous systems have to be described explicitly and electrodynamic interactions can be treated perturbatively do not suffice for accounting for all phenomena.

As to implications of our SDVSASES analyses, these expound characteristic of aqueous systems, knowledge of which is of vast importance for basic research and technology. As to basic research, we suffice with mentioning that it is well known that the customary electrostatic theories hitherto cannot explain numerous properties of aqueous systems. The noticeable role of electrodynamic interactions in SDVSASES renders it a good test case for studying their effects. For example, their effects on electron transfer between bio-molecules, as we discuss in the following paper in this jour-

nal's issue (Yinnon and Liu, 2015b). As to technological relevance, serial dilutions and vigorous shaking affecting ferroelectric ordering in water have implications for ferroelectric materials' production and liquid films' technology, *e.g.*, water film mixers (Liu *et al.*, 2013).

The abovementioned stresses that future research of SDVSASES is desirable. In addition to the various research projects mentioned in the previous section, we foremost propose:

(a) Isolating domains from SDVSASES and studying these with the techniques em-

ployed for Iterative Nafionized Water's domains (Elia *et al.*, 2013; Yinnon *et al.* 2015c), and delineating these domains characteristics' dependence on the concentration of SDVSASES for $\sim 10^{-20} \text{ M} < C < \sim 10^{-3} \text{ M}$.

(b) Studying the effects of EMFs on isolated SDVSASES domains.

(c) Identifying solute characteristics determining the critical concentration below which CD_{rot} can form.

(d) Quantitative analyses and computer simulations complementing our qualitative study.

Table 1: List of abbreviations in alphabetic order, followed by Greek symbols abbreviations.

Abbreviations	Explanation
A	Amplitude
C	Concentration
C_{crit}	Critical concentration
$C_{\text{crit}}^{\text{CDrot}}$	Critical concentration below which CD_{rot} may form
$C_{\text{trans}}^{\text{CDplasma}}$	Transition concentration for $\text{CD}_{\text{plasma}}$ formation
$C_{\text{trans}}^{\text{IPDplasma}}$	Transition concentration for $\text{IPD}_{\text{plasma}}$ formation
C_{thr}	Threshold concentration below which no domains are present in SDVSASES samples screened by Permalloy
CD	Coherence domain
$\text{CD}_{\text{elec}}^{\text{H}_2\text{O}}$	Coherence domain composed of coherent electronically excited water molecules
$\text{CD}_{\text{plasma}}$	Coherence domain composed of few solvated solutes performing coherent plasma oscillation and numerous polar solvent molecules
CD_{rot}	Coherence domains of ferroelectric ordered polar solvent molecules
DLS	Dynamic light scattering
$\text{EDA}^{\text{CDrot}}$	Excited or broken CD_{rot} piece, which has an electric dipole moment and therefore is denoted electric dipole aggregate (EDA)
$\text{EDA}^{\text{IPDplasma}}$	Excited or broken $\text{IPD}_{\text{plasma}}$ piece, which has an electric dipole moment and therefore is denoted electric dipole aggregate (EDA)
EMF	Electro-magnetic fields
eV	Electron Volt
H_2O	Water molecule
$\text{IPD}_{\text{plasma}}$	In phase domains composed of few solvated solutes and numerous solvent molecules performing in phase plasma oscillation.
IR-SPBCF	Infra red spectra pass band coefficient fluctuations
K	Kelvin
M	Molarity in mol per liter
m	meter
QED	Quantum electro-dynamics
SDVSASES	Serial diluted vigorous shaken aqueous strong electrolyte solution
Supra-CD	Agglomerate of coherence domains
UV	Ultra-violet
$\Lambda(C)$	Molar electric conductivity as function of concentration
$\Lambda(t)$	Molar electric conductivity as function of time
χ	Electric conductivity in $\mu\text{S cm}^{-1}$
χ_{lb}	Electric conductivity of samples kept on laboratory bench
χ_{p}	Electric conductivity of samples kept in Permalloy containers

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References

- Arani R, Bono I, Del Giudice E; Preparata G (1995). QED coherence and the thermodynamics of water. *Int J Mod Phys B* 9: 1813-1841.
- Arakawa M, Kagi H, Fukazawa H (2009). Laboratory measurements of infrared absorption spectra of hydrogen-ordered ice: a step to the exploration of ice XI in space. *Astrophys J Suppl Series* 184: 361-370.
- Belon P, Elia V, Elia L, Montanino M, Napoli E, Niccoli M (2008). Conductometric and calorimetric studies of the serial diluted and agitated solutions -- On the combined anomalous effect of time and volume parameters. *J Therm Anal Cal* 93: 459-469.
- Chai BH, Zheng JM, Zhao Q, Pollack GH (2008). Spectroscopic Studies of Solutes in Aqueous Solution. *J Phys Chem A* 112: 2242-2247.
- De Ninno A, Congiu Castellano A (2011). Co-ordination of water molecules in isotopic mixtures. *J Mol Struct* 1006: 434-440.
- De Ninno A, Congiu Castellano A, Del Giudice E (2013). The supramolecular structure of liquid water and quantum coherent processes in biology. *J Phys: Conf Ser* 442: 012031 p.1 to 9.
- Del Giudice E, Preparata G, Vitiello G (1988). Water as a free electric dipole laser. *Phys Rev Lett* 61: 1085-1088.
- Del Giudice E, Preparata G (1998). "A new QED picture of water", in *Macroscopic Quantum Coherence*, eds. Sassaroli E, Srivastava YN, Swain J, Widom A. (World Scientific, Singapore).
- Del Giudice E, Preparata G, Fleischmann M (2000). QED coherence and electrolyte solutions. *J Electroanal Chem* 482: 110-116.
- Del Giudice E, Vitiello G. (2006). Role of the electromagnetic field in the formation of domains in the process of symmetry-breaking phase transitions. *Phys Rev A* 74: 022105-1-022105-9.
- Del Giudice E, Spinetti PR and Tedeschi A (2010). Water dynamics at the root of metamorphosis in living organisms. *Water* 2: 566-586.
- Del Giudice E, Tedeschi A, Vitiello G, Voeikov VL (2013). Coherent structures in liquid water close to hydrophilic surfaces. *J Phys: Conf Ser* 442: 012028.
- Elia V, Niccoli M (1999). Thermodynamics of Extremely Diluted Aqueous solutions. *Ann New York Acad Sci* 870: 241-248.
- Elia V, Niccoli M (2000). New Physico-chemical properties of water induced by mechanical treatments: A calorimetric study at 25°C. *J Therm Anal Cal* 61: 527-537.
- Elia V, Niccoli M (2004a). New Physico-chemical properties of extremely diluted aqueous solutions. *J Therm Anal Cal* 75: 815-836.
- Elia V, Napoli E, Niccoli M, Nonatelli L, Ramaglia A, Ventimiglia E (2004b). New Physico-chemical properties of extremely diluted aqueous solutions. *J Therm Anal Cal* 78: 331-342.
- Elia V, Napoli E, Niccoli M, Marchettini N, Tiezzi E (2008). New physic-chemical properties of extremely dilute solutions. A conductivity study at 25°C in relation to aging. *J Solution Chem* 37: 85-96.
- Elia V, Napoli E (2010). Dissipative structures in extremely diluted solutions of homeopathic medicines. A molecular model based on physico-chemical and gravimetric evidences. *Int J Des Nat* 5: 39-48.
- Elia V, Ausanio G, De Ninno A, Gentile F, Germano R, Napoli E, Niccoli M (2013). Experimental evidence of stable aggregates of water at room temperature and normal pressure after iterative contact with a Nafion® polymer membrane. *WATER Journal* 5: 16-26.
- Elia V, Germano R, Napoli E, (2015). Permanent Dissipative Structures in Water: The Matrix of Life? Experimental Evidences and their Quantum Origin. *Curr Top Med Chem* 15: 559-571.
- Fontana MP (1994). Raman and IR fluctuation spectroscopy of liquid crystals, in: *The molecular dynamics of liquid crystals*. Luckhurst GR and Veracini CA, Kluwer Acad Pub, The Netherlands. p.403-430.
- Georgalis G, Kierzek AM, Saenger W (2000). Cluster Formation in Aqueous Electrolyte Solutions Observed by Dynamic Light Scattering. *J Phys Chem B* 104: 3405-3406.
- Ho M-W (2014). Large Supramolecular Water Clusters Caught on Camera - A Review. *WATER Journal* 6: 1-12.
- Horne RA (1971). Water and Aqueous Solutions: Structure, Thermodynamic and Transport Processes. Wiley-Interscience New York. Chapters 8-12.

- Konovalov AI, Ryzhkina IS (2014). Reviews: Formation of nanoassociates as a key to understanding of physicochemical and biological properties of highly dilute aqueous solutions. *Russ Chem Bull Int Ed* 63: 1-14.
- Kožíšek F, Auerbach D, Gast MKH, Lindner K (2013). Comment on: "Evidence for the existence of stable-water-clusters at room temperature and normal pressure" [Phys. Lett. A 373 (2009) 3872] in *Phys Lett A* 377: 2826-2827.
- Li L, Ogawa T (2000). Clusters and their properties in aqueous solutions of KDP, KCl and sugar. *J Cryst Growth* 211: 286-289.
- Liu ZQ, Li YL, Gan KY, Jiang SR, Zhang GC (2013). Water film washers and mixers: their rotational modes and electrohydrodynamical flows induced by square-wave electric fields. *Microfluid Nanofluid* 14: 319-328.
- Lo S-Y (1996a). Anomalous state of ice. *Mod Phys Lett* 10: 909-919.
- Lo S-Y, Lo A, Chong LW, Tianzhang L, Hua LH, Geng XU (1996b). Physical properties of water with I_E structures. *Mod Phys Lett* 10: 921-930.
- Lo S-Y, Li W (1999). Onsagers's formula, conductivity and possible new phase transition. *Mod Phys Lett B* 13: 885-893.
- Lo S-Y, Geng XU, Gann, D (2009). Evidence of stable-water-clusters at room temperature and normal pressure. *Phys Lett A* 373: 3872-3876.
- Lo S-Y (2013). Reply to the Comment by F. Kožíšek et al. On "Evidence for the existence of stable-water-clusters at room temperature and normal pressure"[Phys.Lett.A373(2009)3872] in *Phys Lett A* 377: 2828-2829.
- Montagnier L, Aissa J, Del Giudice E, Lavallee C, Tedeschi A, Vitiello G (2011). DNA waves and water. *J Phys: Conf Ser* 306: 012007.
- Nakamura Y, Ohno T (2011). Ferroelectric mobile water. *Phys Chem Chem Phys* 13: 1064-1069.
- Preparata G (1995). *QED Coherence in Matter*. World Scientific, Singapore, New Jersey, London, Hong Kong.
- Raine SR, So HB (1993). An energy based parameter for the assessment of aggregate bond energy. *J Soil Science* 44:249-259.
- Robinson RA, Stokes RH (2002). *Electrolyte Solutions*. Dover Publications Inc., Mineola, New York. Chapters 1-3.
- Ryzhkina IS, Murtazina LI, Masagutova EM, Mishina OA, Pavlova TP, Fridland SV, Academician Konovalov AI (2012). Self-Organization of Sodium Chloride Solutions in the Absence and Presence of a Biologically Active Substance of Low Concentration under Common and Hypoelectromagnetic Conditions. *Dokl Phys Chem* 446:184-189.
- Samal S, Geckeler KE (2001). Unexpected solute aggregation in water on dilution. *Chem Commun* 2224-2225.
- Sedlak M (2006) Large-scale supramolecular structure in solutions of low molar mass compounds and mixtures of liquids. *J Phys Chem B* 110: 4329-4338; 4339-4345; 13976-13984.
- Sedlak M, Rak D (2013) Large-scale inhomogeneities in solutions of low molar mass compounds and mixtures of liquids: Supramolecular structures or nanobubbles? *J Phys Chem B* 117: 2495-2504.
- Sivasubramanian S, Widom A, Srivastava YN (2005). The Clausius-Mossotti phase transition in polar liquids. *Physica A* 345: 356-366.
- Wong C, Lo S-Y (1998). Possible mechanism of formation and stability of anomalous state of water, in: Lo S-Y, Bonavida B (Eds.), Proceedings of the 1st International Symposium on Physical, Chemical and Biological Properties of Stable Water Clusters. World Scientific, p. 48-63.
- Yinnon CA, Yinnon TA (2009). Domains in aqueous solutions: theory and experimental evidence. *Mod Phys Lett* 23: 1959-1973.
- Yinnon TA, Yinnon CA (2011). Electric dipole aggregates in very dilute polar liquids: Theory and experimental evidence. *Int J Mod Phys B* 25: 3707-3743.
- Yinnon TA, Yinnon CA (2012). Domains of solvated ions in aqueous solutions, their characteristics and impact on electric conductivity: theory and experimental evidence. *Mod Phys Lett B* 26: 1150006, 1-14.
- Yinnon TA, Elia V (2013). Dynamics in perturbed very dilute aqueous solutions: theory and experimental evidence. *Int J Mod Phys B* 27: 1350005, 1-35.
- Yinnon TA, Liu Z-Q (2015a). Domains Formation Mediated by Electromagnetic Fields in Very Dilute Aqueous Solutions: 1. Quantum Electrodynamical Aspects. *WATER Journal* 7: 33-47.
- Yinnon TA, Liu Z-Q (2015b). Domains Formation Mediated by Electromagnetic Fields in Very Dilute Aqueous Solutions: 3. Quantum Electrodynamical Analyses of Experimental Data on Solutions of Weak Electrolytes and Non-electrolytes. *WATER Journal* in Press.
- Yinnon TA, Elia V, Napoli E, Germano R, Liu ZQ (2015c). Water ordering induced by interfaces: an experimental and theoretical study. *WATER Journal* in Press.
- Zubareva GM, Kargapolov AV, Yaguzhinskii LS (2003a). Fluctuations of pass band coefficients of water and salt solutions in the Infrared Region of the spectrum. *Biofizika (Moscow)* 48: 197-200.
- Zubareva GM, Kargapolov AV, Laguzhinskii LS (2003b). Specific effect induced by subminute amounts of ascorbic acid on the fluctuation of transmission factor of water in the infrared spectral range. *Dokl Biochem Biophys* 388: 43-45.

Discussion with Reviewers

Reviewer: Is there a relationship between the “supra CD”, *i.e.* formation of super coherence domains and the possibility that aggregates of water molecules (negatively charged) can lead to the formation of solids via like-likes-like interaction? In other words, is the presence of a solid residue after evaporation at room pressure and temperature, which can be detected by Atomic Force Microscopy (AFM), an indication that we are in the presence of solid water under normal conditions?

Yinnon T and Liu Z-Q: To answer this question, we emphasize the following aspects of supra-CD in aqueous systems.

a) Within a coherence domain (CD), part or all of its molecules coherently transit between two states, *e.g.*, electronic, rotational or plasma states. The photons involved in the transitions are condensed within the domain. CD may agglomerate in supra-domains. Supra-CD are not just ensembles of molecules but agglomerates of domains, like domains in liquid crystals. The energy gained by close packing of CD is related to the overlap of the evanescent tails of their photons' condensed EMF. The overlap causes the coherent transitions of a CD's molecules to be coherent with those ones in all other CD constituting the supra-CD. For example, in a supra-CD_{elec}^{H₂O}, all H₂O coherently oscillate between their electronic ground state and an excited state.

b) CD_{plasma} and IPD_{plasma} are electrically neutral domains. Hence the energetics underlying their agglomeration into supra-domains is of the type mentioned in the previous paragraph.

c) CD_{rot} have an electric dipole moment. Therefore the physics underlying CD_{rot} agglomerating into supra-CD_{rot} can be viewed as alignment of their electric

dipoles, as well as that specified in paragraph (a).

d) CD_{elec}^{H₂O}, due to their quasi free electrons, easily get negatively charged. Data obtained with electrophoresis by the group of Konovalov and Ryzhkina (2014) indicate that the electrokinetic potential of CD_{elec}^{H₂O} and supra-CD_{elec}^{H₂O} varies between -2 to -20 mV (Yinnon and Liu, 2015b). Energy gained by agglomeration of CD_{elec}^{H₂O} into supra-CD_{elec}^{H₂O} at least includes that specified in paragraph (a). It is also conceivable that energy is gained by the cloud of quasi free electrons of each CD_{elec}^{H₂O} spreading over the whole supra-domain, and their quasi free protons reorganizing. However, to the best of our knowledge, this hypothesis has not yet been investigated.

In regards to the above mentioned, for CD_{elec}^{H₂O} with their negative electric charges and for CD_{rot} with their asymmetric electric charge distributions we can ponder if these agglomerate into, respectively, supra-CD_{elec}^{H₂O} and supra-CD_{rot} via “like likes like” interaction. This type of interaction refers to the phenomenon of attraction between like-charged particles. Such interaction counters our electrostatic theory based intuition. An often cited example of this phenomenon is the attraction between like-charged colloidal particles. Langmuir (1938), Feynman (1963) and others attributed the phenomenon to counter-ions situated in between the like-charged particles, *i.e.*, “like-likes-like through an intermediate of unlikes”. Pollack and his co-workers recently provided experimental data confirming this attribution for like-charged beads in deionized water.

For CD_{elec}^{H₂O} agglomerated into supra-CD_{elec}^{H₂O} it indeed is possible that the quasi free protons constitute the “intermediate of unlikes”. However, it also is possible that within a supra-CD_{elec}^{H₂O}, the quasi free electrons with their non-local quantum physics qualities spread over the whole supra-

domain. As to experimental data providing any clues, we refer to the rounded domains with diameters of about 1×10^{-7} m - 5×10^{-7} m located within 10^{-4} m long strips, observed by transmission electron spectroscopy (see paragraph vi in the Discussion section). We inferred that the long strips are CD_{rot} and the 1×10^{-7} to 5×10^{-7} m sized domains are $CD_{elec}^{H_2O}$ and supra- $CD_{elec}^{H_2O}$. Our inference implies that the diameters of supra- $CD_{elec}^{H_2O}$ in SDVSASES reach maximal sizes of about 5×10^{-7} m. In serial diluted solutions of weak or non-electrolytic compounds with concentration in the range of 10^{-10} - 10^{-20} M, similar sized supra-domains were observed with DLS by the group of Konovalov and Ryzhkina (2014), which were shown to have characteristics of $CD_{elec}^{H_2O}$ (Yinnon and Liu, 2015b). The x80,000 magnifications of the transmission electron spectroscopy images [see Figures 3d and f in Lo (1996a)] gives the impression that: each $\sim 5 \times 10^{-7}$ m supra-domain is a single entity; intra-domain water is present in between these supra-domains. The data hint that the quasi free electrons spread over the entire supra- $CD_{elec}^{H_2O}$.

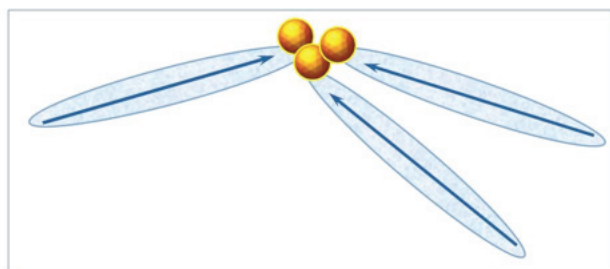


Figure 2: A supra- CD_{rot} . Its CD_{rot} interact through “like likes like” interactions, with $CD_{elec}^{H_2O}$ constituting the “intermediate of unlikes”. CD_{rot} are symbolized by the elongated domains. Their blue arrows symbolize their electric dipole moments. The yellow-brown balls symbolize $CD_{elec}^{H_2O}$.

For supra- CD_{rot} , it is possible “like likes like” interactions underlie agglomeration of their CD_{rot} , with $CD_{elec}^{H_2O}$ or supra- $CD_{elec}^{H_2O}$ playing the role of the “intermediate of unlikes”, as shown in Figure 2.

A solid residue left over after evaporation at room pressure and temperature of serial di-

luted vigorous shaken aqueous solutions, to the best of our knowledge, was only reported for: solutions with concentrations above 10^{-10} M (Konovalov *et al.*, 2014; Lo, 1996a); for solutions containing large amount of impurities due to their preparation in glass vessels, *e.g.*, impurities like H_2BO_3 , H_4SiO_4 and Na_2CO_3 present at concentrations in the range of 10^{-4} - 10^{-7} M (Elia *et al.*, 2010). AFM showing that the residue left over after evaporation of these solutions contains domains with diameters reaching 10^{-5} m indeed indicates these are mainly composed of H_2O . However, more data is required for concluding that the residue is “solid water under normal conditions”.

Recently, associates were stabilized in water by iterative agitating it with a Nafion membrane (Elia *et al.*, 2013, 2015). The concentration of impurities was of the order of 10^{-6} M. The residue left over after evaporating the liquid at ambient conditions, or freeze-drying it, was investigated with various techniques. Analyses of the experimental data indicate that this solid residue indeed is “solid water under normal conditions” with the H_2O being ordered in supra- CD_{rot} containing supra- $CD_{elec}^{H_2O}$, *i.e.*, [supra- CD_{rot} <supra- $CD_{elec}^{H_2O}$ >] (Yinnon *et al.*, 2015c). This solid water is a new phase of water, which has thermodynamic and spectral characteristics corresponding to those predicted by QED. Similar analyses of the residue left over after evaporating SDVSASES (containing only very few impurities) are called for to show this also is a solid phase of water at normal conditions with H_2O all ordered in [supra- CD_{rot} <supra- $CD_{elec}^{H_2O}$ >].

DWR References

Feynman RP, Leighton RB, Sands M (1963). The Feynman Lecture on Physics. Addison-Wesley, Reading, MA, ch. 2, p. 2.

Langmuir I (1938). The Role of Attractive and Repulsive Forces in the Formation of Tactoids, Thixotropic Gels, Protein Crystals and Coacervates. [J Chem Phys 6: 873-895.](#) ■