Supplementary material

A Appendix: Nuclear polymer Lemmas

The following assumptions are built into or emerge from this Cordus theory, and expressed as lemmas. These should be interpreted as proposed statements of causality. The lemmas represent the Cordus mechanics, and are a mechanism to ensure logical consistency within the theory. A previous paper describes the precursor lemmas (NP.1) for the synchronous interaction [17].

NP.2 REQUIREMENTS FOR A CISPHASIC (#) ASSEMBLY

NP.2.1 The assembly must meet the HED stability criteria. These include the need for have integer charge and balanced loading of discrete forces across the three emission directions (HEDs). Cisphasic assemblies are only available to particules that can *complement* each other regarding filled/unfilled HEDs, such that the assembly still meets the requirements for stability. Thus a p#n cisphasic bond is highly advantageous to the proton and neutron, and next is a pxp transphasic bond, with a p#p cisphasic assembly being the least attractive to the proton.

NP.2.2 Similar frequency: In the typical case of dissimilar participants, the frequencies of the particules need to be sufficiently similar to enable a common assembly frequency to be negotiated. In the case of the proton and neutron their rest masses are similar. Assemblies of particules with disparate frequencies (rest masses) are allowed, but the lighter particule will need to be in an energetic state (hence higher frequency). Alternatively, the particules will need to select harmonic frequencies. This is proposed as the reason for the discrete energy levels of electron orbitals.

NP.2.3 In-phase or cisphasic: The particules need to be in phase with each other, i.e. at least one reactive end from each needs to energise at the same time in the same location.

NP.2.4 Suitable Orientation: The particules need to be orientated to a suitable frame of reference (3D reference plane). This too can be negotiated during assembly. This generally means that the spans of particules are oriented in increments of 90^o to each other.

NP.3 REQUIREMENTS FOR TRANSPHASIC (X) ASSEMBLY

NP.3.1 The particules need to be sufficiently similar in HED structures as to confer an advantage in doing this. Proton chains (pxpxp..) and neutron chains (nxnxn..) have transphasic bonds. However protons preferentially bond cisphasically with neutrons.

NP.3.2 The particules are co-located at one or both reactive ends.

NP.3.3 The co-located reactive ends need to have opposite phase.

NP.3.4 Open and closed configurations are possible (see below).

NP.4 OPEN AND CLOSED NUCLEAR POLYMERS

NP.4.1 For reasons of creating more complete discrete force aggregates, the proton and neutron prefer both their reactive ends to be assembled with the reactive ends of other particules. In the case of the neutron this preference is strong, but weaker for the proton. Consequently nuclei tend to consist of closed chains of protons and neutrons, hence ‘nuclear polymer’.

NP.4.2 A nuclear polymer is a series of nucleons bonded in a network. The polymer has approximately orthogonal joints between particules. The polymer is generally a closed loop, for reasons of HED completion (hence stability). The exception is the single proton, and proton-ended chains, which may be stable while being open.

NP.4.3 Nucleons may be bonded in series. The linear bonds, which make up the series components of the nuclear polymer, are identified in Figure A1. The chain may consist of p#n units in alternating order, using cisphasic bonds. The chain may consist of neutrons bonded end-to-end with transphasic bonds (nxn). Purely proton cisphasic chains (p#p) are forbidden. This is because they repel with the strong force and thus give no advantage to the assembly. However proton-proton transphasic joints (pxp) are acceptable.

NP.4.4 Network structures with crosslink bridge structures are possible. Specific rules apply to the arrangement of cross-bridges. Some arrangements are non-viable. See Figure A2.

NP.4.5 A variety of cis- and transphasic bonds may be used in the assembly of the nuclear polymer, but there may be consequences for stability. See Figure A3 for illustrations.

NP.4.6 The synchronous interaction (strong force) is directional and propagates to neighbouring particules. All particules in a nuclear assembly are synchronised, at least to a harmonic of the common frequency.

NP.5 ASSEMBLY STRUCTURES OF NUCLEAR POLYMERS

NP.5.1 Bonds between two nucleons may be cis- or transphasic, and depending on the participants, result in stable, unstable, or non-viable outcomes.

NP.5.2 *Stable* bonds, as the name suggests, are those that have enduring stability.

NP.5.3 *Unstable* bonds are those that will exist for a time, but will decay with time. Nuclear polymers made of these bonds will have a finite life [23]. The reason such bonds decay is attributed to perturbations of external discrete forces (Cordus: *fabric)* interfere with and destabilise the synchronous interlock of the discrete forces [23]. Transphasic bonds are much weaker at rejecting this interference, because only one reactive end in the assembly is energised (as opposed to both reactive ends being simultaneously energised for cisphasic interactions) and are therefore the weakest link in the nuclear polymer [23].

NP.5.4 *Non-viable* bonds are specific interactions of protons and neutrons that are incompatible with the synchronous interaction. These assemblies will not form at all. An example is proton-proton cisphasic bonding, where there is no complementarity between the discrete forces: both particules are attempting to simultaneously exert three outward and two inward discrete forces and these are incompatible. These assemblies thus repel each other with the same vigour of the synchronous force that holds other particules together. Non-viable assemblies also include assembly shapes that are spatially inaccessible to the polymer, though these are not evident in the simple structures of the light nuclides.

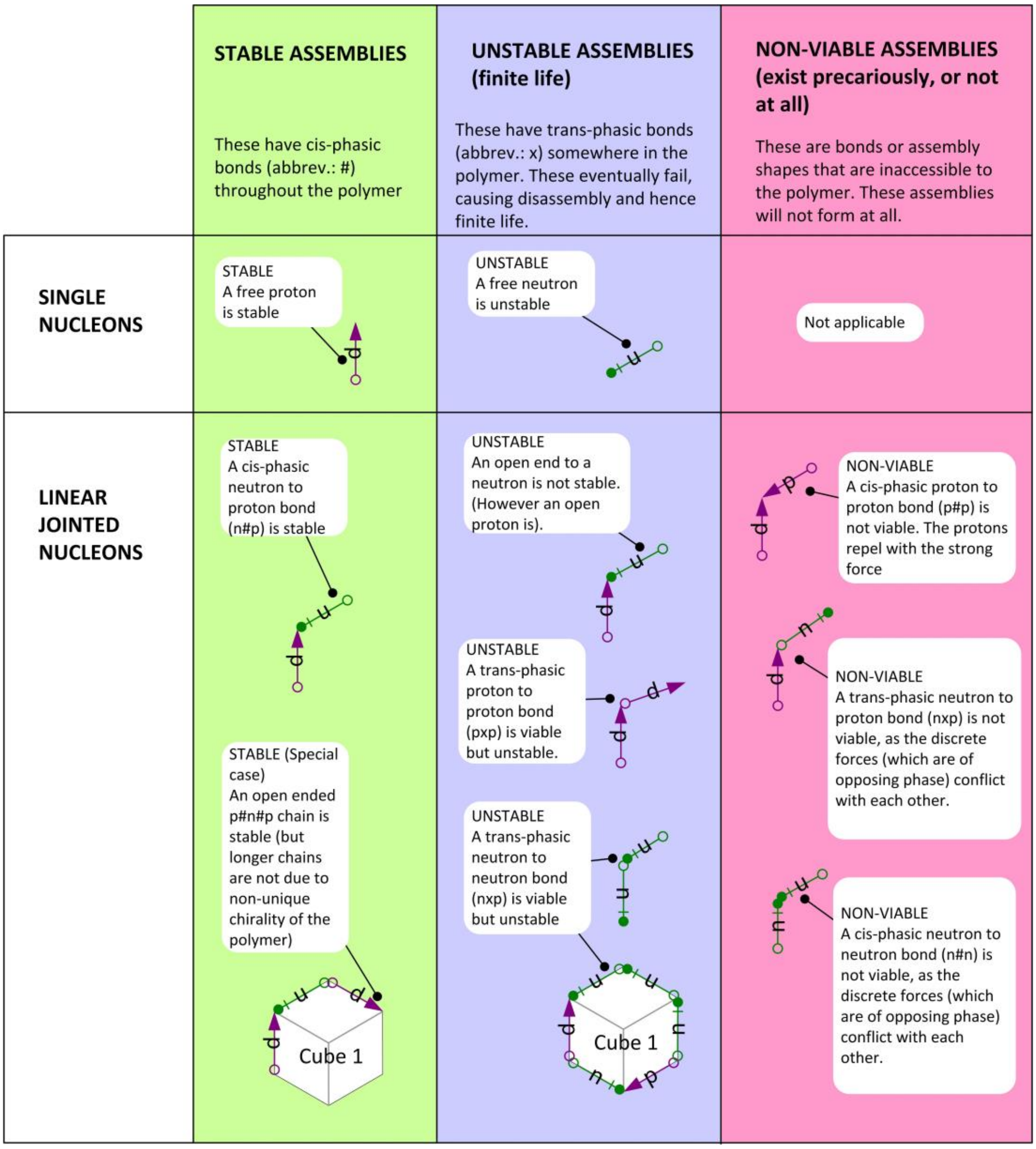

Figure A1: Linear bonds between two nucleons may be cis- or transphasic, and depending on the participants, result in stable, unstable, or non-viable outcomes.

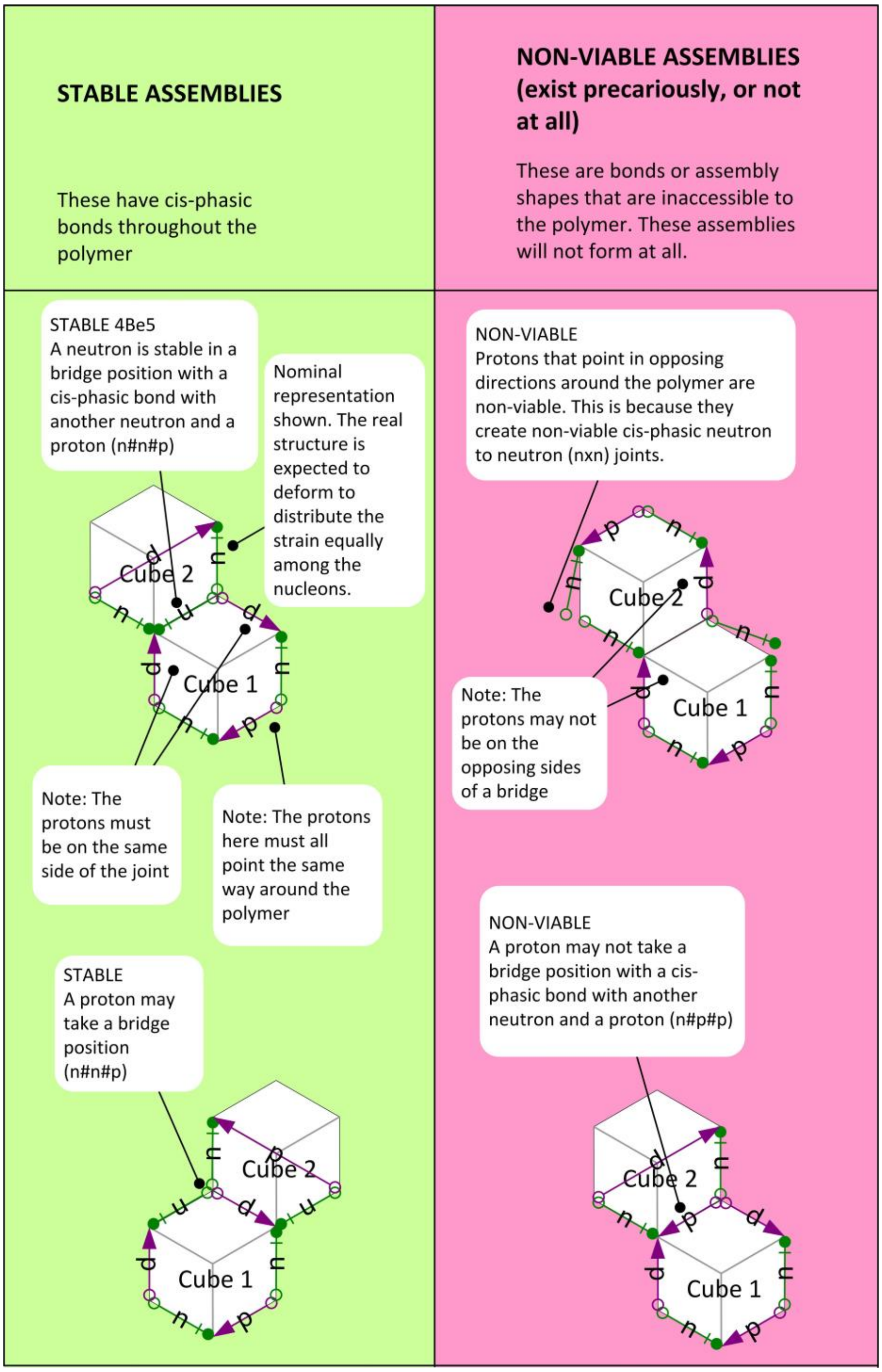

Figure A2: Specific rules emerge for the arrangement of cross-bridges. Some arrangements are non-viable.

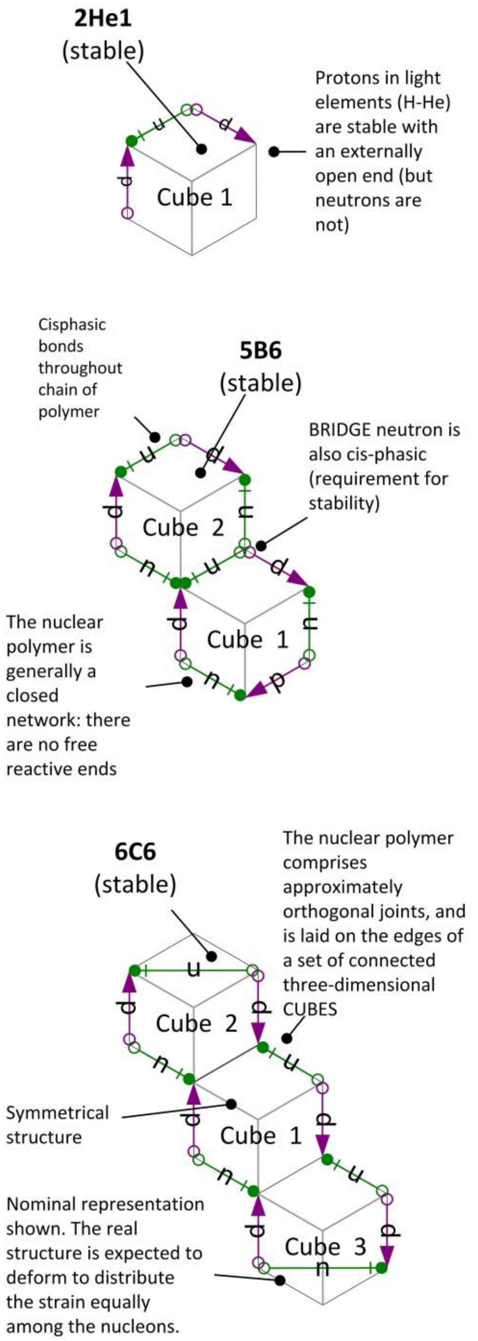

Figure A3: The synchronous interaction (strong force) bonds protons and neutrons together in a variety of way, resulting in nuclear polymer structures. These are proposed as the structure of the nucleus.

These new lemmas are consistent with those already in the wider Cordus set, so no rework of prior assumptions is necessary. This confirms the theory has internal construct validity.