1. Introduction

"What is it that confers individuality upon particulars?"

Options:

1. Individuality is metaphysically basic and cannot be analyzed further.
2. Individuality has no ontological status whatsoever.
3. Individuality is something 'transcending' the attributes of a particular.
4. Individuality is the set (or some subset) of all attributes predicated of the particular.
5. Individuality is some relation holding between the attributes.

Note that 'attributes' is restricted to include only physical ones.

The answer French is interested in is #3. Now, what could this something transcendent be?

i) A Lockean substantial substratum
ii) The space-time point(s) at which the individual exists

Apart from this question of what confers individuality, there is also the question of what confers re-identification, that is, what allows us to infer that b at t is the same as c at t'. A basic set of necessary conditions for this is given: b and c should be connected by a spatiotemporal path/trajectory such that:

a) The trajectory is spatiotemporally continuous (f: [t, t']-> [b, c] is a continuous function)
b) The trajectory is qualitatively continuous (f(x) is "qualitatively similar" to all f(x+e) where $0<e<d$ for some d)
c) The trajectory should be formulable as a succession of sortal-stages (typically, "particle").

Now, for some reason, nobody likes i) much. It's also not as metaphysically parsimonious as ii): It posits a substratum which confers individuality alongside spacetime points which allow us to infer re-identifiability (as discussed above); ii), on the other hand, asserts that spacetime points both confer and allow us to infer the respective things.

But ii) has issues, too.

Regarding spatiotemporal location:

a) Holding it to be an attribute means individuality is acquired through a certain privileged attribute, which has "deficiencies" (no elaboration offered).
b) If taken to be "external" to the individual, we have the question of how individuality can be conferred by something external to the individual.

Regarding spacetime:

a) If taken to be absolute, we fall into a regress attempting to account for the individuality of spacetime points.
b) If taken to be relational, we once again fall into a regress, since the individuality of one entity ends up involving its relationship with other individuals.

A remark is made on the failure of Leibniz's law: Two electrons (say) are indistinguishable (their set of attributes are identical), but not identical.

2. Classical mechanics

OK: How does individuality enter the picture in classical mechanics?

By virtue of the probabilities made to associate with the arrangement of particle-ensembles. The fact that the arrangement (3) has double the weightage of (1) and (2) (due to the permutations) tells us that the two particles are not identical. Now, let's look at how this matches up with the views discussed above.

Proponents of view i) may claim that there's a substratum which allows for distinct permutations. Conversely, proponents of ii) may claim that the distinction between the particles' spatiotemporal positions are what enable them to permute.

But even after we have the different arrangements in our hands, there remains the question of justifying their *equiprobability*; the assignment of "equal a priori probabilities"—which is certainly necessary to allows a particle's individuality to come forth (consider: nothing could have been said on the matter if 1), 2) and 3) were all assigned weightage 1, instead).

"The justification of the above…is one of the most fundamental problems in statistical mechanics." What does the answer to it tell us about the necessity and sufficiency of i) in explaining individuality?

a) The ergodic approach:
   So, i) is not sufficient.
b) The empirical approach: The law is justified by its well confirmed empirical consequences. In this case, i) is sufficient, but not necessary.
c) The axiomatic approach: The law is included as an axiom of the theory. In this case, i) is sufficient, but not necessary.

i) not necessary in approaches b) and c), because ii) is still perfectly capable of offering an equally good account of individuality in those cases. Here's how:

Instead of viewing a particle at (x, y), we speak of a property (say, that of impenetrability) being manifested at (x, y). As Newton noted, any classical particle theory is formulable in field-theoretical terms. And having thereby replaced material substance with property, i) no longer stands.

This property may manifest in box 1 twice, or box 2 twice, etc. We call each manifestation a 'blip'; individuality is conferred upon this 'blip' via its spatiotemporal location, and trans-temporality is given by its satisfaction of the conditions given in the first section (only difference: the sortal is 'blip'). ii) did it!

Now, we may have the equiprobability of arrangements by b) or c), but how do we maintain that the permutations in 3) are two genuinely distinct arrangements under ii)?

We require two parameters to describe the system (the x-axis positions of the manifestations of impenetrability). We thus represent it as a point in a two-dimensional coordinate system. Imagine moving along the x-axis to correspond to blip 1 moving rightward; and along the y-axis to blip 2. It should become diagrammatically clear now that we have managed to 'fold out' singular arrangement in blip space such as 3) into two arrangements in phase space.

"It is worth recalling...that although there is clearly an ontological difference between the particle and the field approaches…no experiment could ever decide which is correct."

"Thus we see that classical statistical mechanics supports both views of individuality outlined in the introduction."

3. Quantum mechanics

Particles of the same species are physically indistinguishable in both classical and quantum mechanics. However, a strong condition—namely, the Indistinguishability Postulate—comes to play in the latter: "Particle permutations are not regarded as observable." The arrangement (3) no longer has double the weightage. The intuitive inference seems to be that particles no longer possess a certain 'individuality', like they did in the classical manner.

But this skims over an important subtlety here. Suppose we have particle a in box 1 and particle b in box 2. There are two ways to view any permutation:

1. Particle permutation: We put particle a in box 2 and particle b in box 2, leaving the positions of the boxes unchanged.
2. Place permutation: We leave the particles untouched and, instead, switch the positions of the boxes. The final result is still particle a in box 2 and particle b in box 1.

While the former act cannot be regarded as an observable, as it so happens, the latter can.

"We therefore arrive at the position where we have non-individual particles and distinguishable, individual states." As such, this leads us right onto view ii) with regards to individuality, because states are always "embedded" in space-time.

But there's another way to go about analyzing the quantum mechanical situation.

Instead of explaining the halved weightage of (3) by saying that we're making a permutation and considering the {(a, 1), (b, 2)} and {(b, 1), (a, 2)} arrangements as identical, we may try to just deny the possibility of a permutation to begin with.

This can be done by an alternative consideration of the Indistinguishability Postulate. Instead of reading it as saying "These two arrangements are the same", it can be read as saying "There are two arrangements, but only one of them satisfies certain extra but necessary physical constraints". As such, both readings would half the weightage of (3).

This reading would allow us to confer upon the particles the same notion of individuality we did in the classical case.

The paper concludes: "We have shown that more than one 'metaphysical package' may be consistent with a given physical theory and that therefore there exists a fundamental under-determination as regards the 'picture' of reality physics commits us to."